THERMODYNAMIC PROPERTIES OF NITROGEN FROM 300 TO 5000°K AND FROM 1 TO 1000 AMAGATS

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ARO, Inc.

August 1966

VON KÁRMÁN GAS DYNAMICS FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE

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FOREWORD

The work reported herein was done at the request of Headquarters, Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), Arnold Air Force Station, Tennessee, under Program Element 65402234.

The results of the research presented were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of AEDC, AFSC, under Contract AF40(600)-1200. The ARO Project No. was VT8002, and the manuscript was submitted for publication on March 10, 1966.

The authors gratefully acknowledge the extensive assistance of F. C. Loper and C. A. Neel of Central Computer Operations, ARO, Inc., and of W. A. Odle and G. E. Gilley of the computation group in the von Kármán Gas Dynamics Facility, ARO, Inc.

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ABSTRACT

Tables for the thermodynamic properties of equilibrium nitrogen are presented at intervals of log ρ = 0.2, the density ρ in amagats extending from one to 1000 amagats, and at intervals of 100 deg in temperature from 300 to 5000°K. In accordance with full discussion in the text of the report, the compressibility factor Z at 300 and 400°K is extrapolated to 1000 amagats by linear extrapolation of log (Z-1) against log ρ at constant temperature. At 3000 and 5000°K the values of Z are found from published virial coefficients. Interpolations between these extremes of temperature are based on an empirical equation for the pressure-temperature lines at constant density, the form of which fits known data at medium densities and also predicts data at temperatures below 300°K. The values of the dimensionless thermal functions E/RT (internal energy) and S/R (entropy) are based on numerical integrations of Z and its derivative $(\partial Z/\partial T)_\rho$, using known values of these functions at one amagat as constants of integration. This method of determining the thermal functions is validated by showing that it reproduces a set of known tables to a high degree of accuracy.

CONTENTS

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TABLES

NOMENCLATURE

a, b, c, e	Parameters (as functions of density) in an empirical equation for pressure-temperature lines at constant density
B	Second virial coefficient in reciprocal amagats
C	Third virial coefficient in reciprocal amagats squared
D	Fourth virial coefficient in reciprocal amagats cubed
E	Internal energy in dimensionless function E/RT
G&B	Symbol for tables given in Appendix I
H	Enthalpy in dimensionless function H/RT
k	Exponent in empirical formula for solidification pressure
ln	Natural logarithm
log	Common logarithm to base 10
p	Pressure, atm
R	Gas constant in dimensionless functions, such as E/RT

S	Entropy in dimensionless function S/R
T	Temperature, °K
y	Generic symbol for ordinate of logarithmic plot
Z	Dimensionless compressibility factor in gas law $p = ZRT\rho$
Z*	Total number of moles/mole at 273.15°K and 1 atm
ρ	Density, amagats
H&K	Symbol for tables of Hilsenrath and Klein (Ref. 2)
L&N	Symbol for tables of Little and Neel (Ref. 1)

SUBSCRIPTS

m	Relating to effects of intermolecular forces
t	Relating to thermally perfect gas

SECTION I
INTRODUCTION

The need for nitrogen tables of this kind has been felt with steadily increasing urgency in the planning of new wind tunnels and other apparatus in the von Kármán Gas Dynamics Facility at Arnold Engineering Development Center and no doubt elsewhere. Except at low temperatures up to 400°K, existing tables do not enter the domain of high densities above 500 amagats, and they also leave significant gaps at medium densities. In addition to interpolations here and there, it is necessary to resort to various methods of extrapolation, because published virial coefficients are not adequate to deal with the situation in its entirety. As is shown in Section II, discreet graphical procedures, or their analytical equivalents, combined with thermodynamic reasoning contribute to an approximate solution of the problem.

Figure 1 shows the thermodynamic domain from 100 to 5000°K up to 1000 amagats. On it are shown the areas covered by three sets of current tables representing available data, namely those of Little and Neel (Ref. 1), Hilsenrath and Klein (Ref. 2), and of Smith (Ref. 3). Those of Ref. 1, which extend from 100 to 1500°K and to various upper density limits, are compiled from Hilsenrath et al (Ref. 4) and from the important tables of Din (Ref. 5), the latter being based in part on the experimental data of Tskilis (Ref. 6) which extend to well over 800 amagats at 300 and 400°K. The tables of Ref. 2 cover the range from 2000 to 15, 000°K from very low densities to 250 amagats, and they include the effects of dissociation and ionization, as well as theoretically determined second virial corrections. Finally, the tables of Ref. 3 extend from 1000 to 7500°K and from very low densities to about 400 amagats, and they were computed from the second, third, and fourth virial coefficients for nitrogen given by Amdur and Mason (Ref. 7) based on measurements of molecular-beam scattering effects. Bridgman (Ref. 8) measured the compressibility of nitrogen at near ambient temperatures up to about 880 amagats, but Din (Ref. 5) chose to disregard these results which can hardly be reconciled with the work of Tsiklis (Ref. 6) and other data.

The equation-of-state data of Ref. 1 are generally based on experimental work and are retained, except for small changes required by the maintenance of thermodynamic conformity with entries at higher temperatures, as dictated by the course of pressure-temperature lines at constant density, the so-called isometrics. Furthermore, if it is assumed that the virials of Amdur and Mason are adequate to allow extrapolation to 1000 amagats at the high-temperature end from 3000 to 5000°K, it follows from consideration of the isometrics that additional

Amdur and Mason virials would be required at high densities in the medium temperature range from 1000 to 3000°K. These considerations are developed in Section 2.4.

SECTION II
DISCUSSION AND PROCEDURE

In broad outline, the tables given in Appendix I are based on (1) graphical extrapolation of the compressibility factor Z to 1000 amagats at 300 and 400°K, (2) the assumtion that the virials of Amdur and Mason suffice to determine the thermodynamic states to 1000 amagats from 3000 to 5000°K, and (3) the use of a discreetly chosen empirical equation whenever necessary to fill in a gap between 400 and 3000°K. The dimensionless thermal quantities E/RT and S/R are developed by numerical differentiation and integration of a carefully prepared array of values of Z, using the known values of E/RT and S/R at one amagat as constants of integration.

2.1 A USEFUL GRAPHICAL DOMAIN

The compressibility factor of a real gas is often computed by means of the equation

$$Z = 1 + B\rho + C\rho^2 + D\rho^3 + \text{etc.}$$

in which the parameters B, C, D, etc., are the virial coefficients which are assumed to be functions only of the temperature. As usually tabulated in the literature, these parameters are merely coefficients in a finite series expansion in integral powers of the density, as determined from experimental data by a numerical curve fitting procedure. In the range of interest of the present work, the number of virial coefficients required generally decreases as the temperature increases.

Below the Boyle temperature (about 323°K for nitrogen) the second virial coefficient B is negative, because the numerical value of Z is less than unity, being approximately 0.3 at the critical point. In theoretical determinations of Z, the coefficient B generally represents interactions between pairs of entities (molecules, atoms, ions). In like manner, the coefficient C pertains to three-particle interactions, and so on. Above the Boyle temperature, the occasional appearance of negative empirically determined virials is probably fortuitous, it having been found (Ref. 9) that a change of one percent or less in a given datum point will occasionally change the sign of a higher virial coefficient in a curve fitting procedure. The literature does not appear to disclose any

negative theoretical virials above the Boyle temperature, and through the remainder of this section it is assumed that all virials are positive above the Boyle temperature.

For the sake of convenience in notation, the virial equation is written in the form

$$Z = 1 + \Delta Z_2 + \Delta Z^3 + \text{etc.}$$

where the ΔZ's are the contributions to Z of the successive virial coefficients beyond the first. In this equation, ΔZ_2 is equal to $B\rho$, so that

$$y = \log \Delta Z_2 = \log B + \log \rho$$

a plot of which with respect to log ρ being a straight line of unit slope whose intercept on the line y = 0 is equal to log (1/B). In the same way, $\Delta Z_3 = C\rho^2$, so that

$$y = \log \Delta Z^3 = \log C + 2 \log \rho$$

which is a straight line of slope 2 intersecting the y = 0 axis at the point $(1/2)\log(1/C)$. The generalization to the n^{th} virial is obvious.

Before considering the interaction of these straight lines on a logarithmic plot, it is worthwhile briefly to see the case of a bivirial gas in which the effects of dissociation are decreasing with increasing density. On completion of recombination, the bivirial gas is represented by the relation

$$Z - 1 = B\rho$$

and

$$\log(Z-1) = \log B + \log \rho$$

Figure 2 shows a semi-log plot of (Z-1) versus log ρ for nitrogen at 8000°K, the data being taken from Ref. 2. It is seen that the curve joins the bivirial line as the effects of dissociation disappear, showing how easily in many instances the effects of dissociation can be distinguished from the virial effects. However, in the present work it is not necessary to resort to this method, because the tables of Ref. 2 list the quantity Z*, which is the value of Z without the virial effects.

The presence of several positive virial lines on the logarithmic plot is illustrated in Fig. 3. Here the straight lines represent the contributions to Z of the second, third, and fourth virials given by Amdur and Mason (Ref. 7) for nitrogen at 3000°K. In addition, there is also a plot of (Z-1) computed from the corresponding virial equation.

To show what is going on, the plot is carried out to 10,000 amagats ($\log \rho = 4.0$) on the assumption that no virials higher than the fourth come into consideration. It is seen that the locus of (Z-1) on the log scale eventually converges very slowly on the straight line representing the highest virial contribution; this will also be seen in another way in Section 2.2. It is also worth noting in passing that the locus of (Z-1) can easily be found graphically when positive virial lines are drawn on logarithmic graph paper. At any given density, (Z-1) is merely the sum of the ΔZ's read off the graph.

2.2 A GENERALIZATION OF THIS DOMAIN

Inasmuch as the tables given in Appendix I begin at 300°K, which is below the Boyle temperature, it is important to examine a generalization of the domain to accommodate numerical values of the compressibility factor less than unity. Such values of Z arise by virtue of negative values of the second virial, and under certain conditions the third may also be negative. When Z is equal to unity, log (Z-1) is equal to minus infinity, and when it is less than unity, log (Z-1) is complex.

This suggests plotting the logarithm of the absolute value of (Z-1), rather than the logarithm of (Z-1) itself. Everything is real in this generalized domain, and the equation for the slope of the curve is unchanged on crossing the singularity. At high densities

$$Z - 1 = B\rho + C\rho^2 + D\rho^3 + \text{etc.}$$

and

$$(\partial(Z-1)\,\partial\rho)_T = B + 2C\rho + 3D\rho^2 + \text{etc.}$$

and by changing the variables on the left-hand side from ρ to $\log \rho$ and from (Z-1) to $\log (Z-1)$ there follows

$$\left(\frac{\partial \log (Z-1)}{\partial \log \rho}\right)_T = \frac{B + 2C\rho + 3D\rho^2 + \text{etc.}}{B + C\rho + D\rho^2 + \text{etc.}}$$

On the other hand, at sufficiently low densities and below the Boyle temperature

$$1 - Z = -(B\rho + 2C\rho - 3D\rho^2 + \text{etc.})$$

and by differentiating and changing the variables as before

$$\left(\frac{\partial \log (1-Z)}{\partial \log \rho}\right)_T = 1 - \rho\left[\frac{C - 2D\rho + \text{etc.}}{B - C\rho + D\rho^2 + \text{etc.}}\right]$$

in which the minus signs in the numerator and denominator cancel each other. These two derivatives can be combined in the statement

$$\left(\frac{\partial \log |Z-1|}{\partial \log \rho}\right) = 1 + \rho \left[\frac{C + 2D\rho + \text{etc.}}{B + C\rho + D\rho^2 + \text{etc.}}\right]$$

It is seen by inspection that, as the density is allowed to increase indefinitely, the derivative approaches the exponent of the highest virial contribution.

Figure 4 shows a plot of log $|Z-1|$ against log ρ for air at 25°C, the points being computed from the array of virials given by Michels et al. (Ref. 10). Also shown as logarithms of absolute values are the negative bivirial line and the lines for the positive third and fourth virials. Since the slope of the curve to the left of the singularity does not exceed unity, it follows that only the second virial is negative, the third being positive.

The main purpose of Fig. 4 is to set forth the arm of the curve to the right of the singularity. It rises steeply from minus infinity at the singularity and bends over to the right with negative curvature. If the third virial were the highest, the curve would join the third virial line. But by virtue of the still higher virials, it traverses a point of inflection and its curvature becomes positive. Since the curvatures in this region are small and because of scatter and rounding-off errors, a fairly long segment of the curve in this region can be approximated by a straight line, especially with an expanded scale for log ρ.

Consideration of Fig. 4 also shows why in this study the domain of log (Z-1) was chosen in preference to log Z. The domain of Fig. 4 is not only more sensitive to rounding-off errors in the tables, but also shows more clearly the effects of the successive virials.

By differentiating the general gas law, $Z = p/RT\rho$, the derivative of log (Z-1) may also be written in the form

$$\left(\frac{\partial \log (Z-1)}{\partial \log \rho}\right)_T = \frac{Z}{Z-1}\left[\left(\frac{\partial \log p}{\partial \log \rho}\right)_T - 1\right]$$

As the density and the compressibility factor increase, the ratio $Z/(Z-1)$ decreases slowly as it approaches unity. On the other hand, the isothermal derivative of log p with respect to log ρ must increase at a fair rate, because of the steadily increasing relative difficulty of compressing a gas at high densities. Furthermore, as will be seen in Section 3.2, nitrogen at 300°K and 1000 amagats cannot be far removed from the solid state in which the derivative $(\partial \log p/\partial \log \rho)_T$ must be very large.

2.3 EXTRAPOLATION TO 1000 AMAGATS AT 300 AND 400°K

The application of the loci of (Z-1) to the isothermal extrapolation of Z to 1000 amagats is shown in Fig. 5 with a logarithmic plot of data for nitrogen at 300°K given in Table I of Little and Neel (Ref. 1). The nine highest points, from log ρ = 2.8 to 2.95, lie clustered about a straight line. Now, a detailed examination of the air data in Fig. 4 shows that their locus of log $|Z-1|$ goes through a point of inflection in the vicinity of log ρ = 2.6. So it is fair to conclude that the nitrogen data of Fig. 5 lie beyond their region of negative curvature and that a straight-line extrapolation is conservative. Prolongation of the straight line in Fig. 5 yields a value of Z = 14.36 at log ρ = 3.0. In like manner, Fig. 6 shows the corresponding data at 400°K, which also define a straight line whose prolongation suggests the value of Z = 13.11 at 1000 amagats.

At this point it is appropriate to examine briefly the anomalous data of Bridgman (Ref. 8) which were taken at 338°K. Their locus of (Z-1) is shown in Fig. 7, together with the nearly corresponding data at 340°K from the tables of Ref. 1 which depend heavily on the experimental work of Tsiklis (Ref. 6). A linear extrapolation of Bridgman's line in Fig. 7 suggests Z = 23 at 1000 amagats, whereas the corresponding value of Z from the Little and Neel line would be about 14. For a moment, this raises the question, whether Bridgman's results might portend the existence of a maximum in Z between 300 and 400°K. This is most unlikely, because the data of Ref. 1 at 200°K suggest a value of Z = 20 at 1000 amagats. Without entering into detail, it is sufficient to say that the results of Bridgman hardly fit into the general pattern of Z and of the isometrics to be discussed in the next section.

2.4 THE ISOMETRIC DOMAIN

In their classic paper Beattie and Bridgeman (Ref. 11), Obert (Ref. 12), and other authors observe that the pressure-temperature lines at constant density, the so-called isometrics, of a real gas have negative curvature (except for effects identified with the critical point) and approach linearity at high temperatures. This is illustrated in Fig. 8 showing the nitrogen isometric at log ρ = 2.0 (100 amagats). Below 600°K, the data are taken from Ref. 1 and from 1000°K upwards from Ref. 3. The small terminal curvature of this isometric at its high temperature end is revealed by drawing a straight line from the 1000 to 5000°K point, noting that its maximum relative deviation from the isometric is of the order of one percent. The fact that the isometric approaches a straight line immediately suggests an empirical equation in the form

$$p = a + bT - c\exp(eT)$$

in which the parameters a, b, c, and e are functions of the density. At a given density, the constants a and b are determined by a straight line through the points at 3000 and 5000°K and, in the exponential correction, the constants c and e are determined by the points at 300 and 400°K. The success of an empirical formula in the above form in representing the data at 100 amagats is shown in the table below:

Temperature	log ρ = 2.0 Pressure Formula	Tables	log ρ = 1.4 Pressure Formula	Tables
300	110.9	110.9	27.51	27.51
600	246.4	246.6	56.62	56.60
1000	422.3	422.6	95.15	95.15
2000	849.5	848.6	190.8	190.8
3000	1269.0	1271.0	286.0	286.2
4000	1685.0	1689.0	381.2	381.3
5000	2101.0	2101.0	476.3	476.2

The isometrics become flatter as the density decreases, so the performance of the formula improves correspondingly, as is shown at the right in the above table for the case of log ρ = 1.4 (25 amagats).

In going to higher densities, the corresponding situation at log ρ = 2.4 (251 amagats) is also shown in Fig. 8. As before, the data at 600°K and below are taken from Ref. 1 and at 1000°K and above from Ref. 3. The performance of the corresponding empirical equation is shown in the table below, as is also that of the case of log ρ = 2.6:

Temperature	log ρ = 2.4 Pressure Formula	Tables	log ρ = 2.6 Pressure Formula	Tables
300	323.4	323.4	715.2	715.2
600	792.8	791.9	1753.0	no data
1000	1375.0	1374.0	2960.0	2900.0
2000	2718.0	2709.0	5563.0	5507.0
3000	3995.0	4009.0	7961.0	7983.0
4000	5252.0	5274.0	10,311.0	10,367.0
5000	6503.0	6505.0	12,650.0	12,656.0

In the case of log ρ = 2.4, the largest relative discrepancy (0.4 percent) occurs at 4000°K. The case of log ρ = 2.6 (398 amagats) begins to show an effect by which at 1000 and 2000°K, the empirical formula tends to run significantly higher than the tables, the relative difference at 1000 deg being 2 percent. This suggests that the Amdur and Mason virials may not be adequate at these temperatures as the density is increased.

As would be expected, the insufficiency of Amdur and Mason virials at moderately high temperatures increases with density. This is to be seen in Fig. 9 which is mainly devoted to the isometric for the case of log ρ = 3.0. The solid line at the low-temperature end represents the extrapolated data at 300 and 400°K described in Section 2.3, whereas the solid line from 1000°K upwards is based on the virials of Amdur and Mason (Ref. 7). These two parts of the curve obviously cannot be joined without incurring a point of inflection, and this would be thermodynamically inadmissible. The empirical equation for this case joins the two solid-line portions of the curve with the dotted line in Fig. 9. The case of log ρ = 2.8 is also shown. It is of interest to observe that the empirical formula for this latter density predicts a pressure of 730 atm at 130°K, whereas the tabulated value in Ref. 1 is 726 atm.

The unexpected success of the empirical formula in predicting the pressure at 130°K and log ρ = 2.8 suggests the possibility of using a formula in the same form as before, in which the parameters a, b, c, and e are determined from pressure data at 200, 300, 400, and 5000°K. This formula is identified as Formula-B in the tables of pressures below in which the results from it are compared with those of Formula-A, the one used hitherto, which is based on pressure data at 300, 400, 3000, and 5000°K. Comparisons are shown at log ρ = 2.4 (251 amagats) and 2.8 (631 amagats). At log ρ = 2.4, the calculated pressures are compared with the entry at 600 deg in Ref. 1 and from 1000°K upwards with entries in Ref. 3. At log ρ = 2.8, the calculated pressures can only be compared with values computed directly from the virials of Amdur and Mason (Ref. 7) whose column in the tables is headed A&M.

log ρ = 2.4

Temperature	Pressure Formula-A	Pressure Formula-B	Pressure Tables
600	792.3	793.2	791.9
800	1088.0	1091.0	
1000	1375.0	1379.0	1374.0
2000	2718.0	2730.0	2709.0
3000	3995.0	4007.0	4009.0
4000	5252.0	5259.0	5274.0
5000	6503.0	6503.0	6505.0

$\log \rho = 2.8$

Temperature	Pressure Formula-A	Pressure Formula-B	Pressure A&M
600	5361	5361	
800	6814	6914	
1000	8101	8264	7441
2000	13,439	13,767	13,125
3000	18,270	18,545	18,280
4000	23,034	23,179	23,175
5000	27,790	27,787	27,787

Except at the boundary values, the evaluations of Formula-B tend to run slightly higher than those of Formula-A, but the differences between them are surprisingly small. At $\log \rho = 2.4$ the differences are considerably less than 1 percent, and at $\log \rho = 2.8$ the greatest difference, which occurs at 2000°K, is only 2.5 percent. At the higher density, Formula-B also suggests that the inadequacy of the Amdur and Mason virials might extend up to the vicinity of 3000°K.

The relatively good agreement between both formulas and the relevant entries in the tables tend to confirm the choice of a formula for the isometrics in the form

$$p = a - bT - c \exp(eT)$$

as being reasonable in the present state-of-the-art. In view of the great difficulties involved in theoretical determinations of the higher virials, this also sets forth the need for experimental determinations of equation-of-state data at high densities (or pressures) up to the highest temperatures attainable in the laboratory.

2.5 COMPUTATIONAL PROCEDURE

The first step in generating the accompanying tables given in Appendix I was obviously the one of tabulating the numerical values of the compressibility factor Z. This was done at intervals of 100 deg from 300 to 1000°K, then at intervals of 200 deg from 1000 to 3000°K, and finally at intervals of 500 deg from 3000 to 5000°K. The density range extends from $\log \rho = 0$ (1 amagat) to $\log \rho = 3.0$ (1000 amagats), entries being made at intervals of 0.2 in $\log \rho$. At all densities from $\log \rho = 1$ (10 amagats) upward, the values of Z were computed by means of the empirical formulas for the isometric pressure, in which the parameters were determined from pressure data at 300 and 400°K in Ref. 1 (extrapolated to 1000 amagats as described in Section 2.3) and from the virials of Ref. 7 at 3000 and 5000°K. This procedure not only took care of the instances at high densities in which the virials of Ref. 7

would have to be augmented to bring the isometrics into thermodynamic conformity with the low-temperature data, but it also smoothed out a few situations at medium and low densities at which the pressures predicted by the virials had to be changed slightly to satisfy the low-temperature conditions. A typical case of this sort occurred at 2000°K and log ρ = 1.0 at which the virials specified a pressure of 74.304 atm, whereas the formula specified 74.238 atm, the difference being of the order of one part in a thousand. In only a few instances at the highest temperatures and at the lower densities, it was necessary to add to the values of Z corrections for the effects of dissociation. These small increments were determined from the values of Z* in Ref. 2 between 3500 and 5000°K for densities from a log ρ of 0.2 to 2.6. The numerical values of the parameters of the empirical formula for the isometrics at the various densities are given in Table I. At densities below 10 amagats, the values of Z were taken from the tables and they required remarkably little smoothing.

The input of thermal data to the computing machine consisted of the numerical values of the dimensionless functions E/RT and S/R at log ρ = 0 and at all temperatures at intervals of 100 deg from 300 to 5000°K. These data were taken from Ref. 1 up to 1000 deg, then from Ref. 3 to 2000 deg, and beyond that from Ref. 2 to 5000°K. Very little smoothing was required. The computing machine was instructed to compute the pressure from the relation

$$p = Z R T \rho$$

and then to integrate the differential equations

$$(\partial E/RT/\partial \ln \rho)_T = -T(\partial Z/\partial T)_\rho$$

$$(\partial S/R/\partial \ln \rho)_T = -T(\partial Z/\partial T)_\rho - Z$$

using the values of E/RT and S/R at log ρ = 0 as initial values. Finally, the dimensionless enthalpy H/RT followed from the relation

$$H/RT = E/RT + Z$$

For the performance of interpolations and differentiations, the computer program applied the method of spline fit described by Landis and Nilson (Ref. 13) as applied by Lewis and Neel (Ref. 14). In this method, the computer represents a column of entries in terms of a set of local cubics, each of which is determined by two neighboring entries, subject to the condition that the first and second derivatives of two neighboring cubics are continuous at the junction point. The computations were made on the IBM 7074 computer at Arnold Center.

Beyond computing the values of Z, no further use was made of the fact that analytical expressions were available for the isometrics. For instance, if the pressure is given by the equation

$$p = a + bT - c \exp(eT)$$

where the parameters a, b, c, and e are known functions of density, then

$$(\partial S/R/\partial \ln \rho)_T = -(1/R\rho)\,[b - ce \exp(eT)]$$

with a corresponding expression for the isothermal derivative of E/RT, which could be integrated numerically. Inasmuch as the spline fit and its accessories were already available as subroutines for the computer, it was felt that no great benefit would accrue from programming the indicated numerical integrations.

In order to verify the practicability of the method adopted for determining the quantities E/RT and S/R and generally to test the computational program, the computer was given the task of reconstructing the tables of Hilsenrath and Klein (Ref. 2), using their values of Z, as well as their values of E/RT and S/R at log ρ = 0, this being done at several temperatures in the vicinity of 2500°K. The results of this comparative test at 2500°K are typical and are shown in the following table, in which the entries taken from Ref. 2 are identified by the symbol H&K:

T = 2500°K log ρ = 1.6	E/RT	S/R
H&K	2.99239	25.3190
Check Run	2.99237	25.3191
log ρ = 2.0		
	E/RT	S/R
H&K	2.99313	24.3094
Check Run	2.99320	24.3095
log ρ = 2.4		
	E/RT	S/R
H&K	2.99499	23.1656
Check Run	2.99524	23.1660

It should be noted that in the tables of Smith (Ref. 3), the thermal functions E/RT and S/R are computed from the virial coefficients and their derivatives. For instance, in the case of E/RT, Smith has

$$E/RT = (E/RT)_t + (E/RT)_m$$

where $(E/RT)_t$ relates to the thermally perfect gas and $(E/RT)_m$ is the increment attributable to intermolecular forces. The equation for this increment, given by Hirschfelder et al. (Ref. 15) is

$$(E/RT)_m = -T\,[\,\rho\,(dB/dT) + (\rho^2/2)\,(dC/dT) + (\rho^3/2)\,(dD/dT)\,]$$

in which B, C, and D are the second, third, and fourth virials given by Amdur and Mason (Ref. 7). There is also a corresponding equation for $(S/R)_m$.

SECTION III
CONCLUDING OBSERVATIONS

3.1 ISOTHERMAL MINIMA OF INTERNAL ENERGY

An isothermal minimum of internal energy is found at high densities in the extrapolated tables of this report and also in Refs. 1 and 3, and the density at which these minima occur decreases as the temperature increases. This may be seen in Fig. 10 which is a plot of E/RT against log ρ for 400, 1200, and 3000°K where minima are found at log ρ = 2.8, 2.4, and 1.2, respectively. In general, a point of minimum internal energy is associated with a maximum in a plot of the compressibility factor with respect to temperature at constant density. This may be seen from the following thermodynamic identity:

$$(\partial\, E/RT/\partial \ln \rho)_T = -T\,(\partial Z/\partial T)_\rho$$

Bridgman (Ref. 8) discussed this minima and why it should occur; however, he was unable to locate it in his experimental studies. He did locate such a point in liquids and solids and felt there should be such a point in gases.

3.2 SOLIDIFICATION OF NITROGEN UNDER HIGH PRESSURES

It is important to inquire whether nitrogen remains in the gaseous state when compressed to 1000 amagats at 300°K. The solidification of nitrogen under pressure appears to have been first observed experimentally by Simon et al. (Ref. 16). The effect is currently of interest to geophysicists who use nitrogen as a pressure medium in studying the polymorphism of minerals. Birch and Robertson (Ref. 17) found by direct measurement that nitrogen solidifies at about 27,400 atm at 20°C. They used improved apparatus based on the previous work of Bridgman (Ref. 18). By extending the straight line in Fig. 5, it follows that at

300°K nitrogen can be expected to solidify at about log ρ = 3.07 (1175 amagats), with a value of Z about 21.4. The solidification pressure is approximately proportional to $(T/T_o)^k$, where T_o is the normal freezing temperature and the exponent k is approximately equal to 1.79 for nitrogen. From this it follows that none of the thermodynamic states in the tables of Appendix I lie in the domain of the solid state. It also follows that at 150°K nitrogen can be expected to solidify well below 1000 amagats.

3.3 INTERCOMPARISONS OF TABLES

Table II shows spot comparisons of entries for Z, E/RT, and S/R given in the tables of Appendix I (G&B) with the corresponding entries in the tables of Little and Neel (L&N), Hilsenrath and Klein (H&K), and Smith. It should also be kept in mind that the sets of entries for the pressure, H/RT, and S/R in Ref. 1 were determined by separate interpolations among entries in the source tables, and the authors of Ref. 1 reported finding internal thermodynamic inconsistencies as great as one-half percent. In other respects the entries in Table II speak for themselves.

There is no pretention to absolute accuracy in the tables of Appendix I, but it is felt that the extrapolations and interpolations are reasonable from an engineering point of view and that they are thermodynamically consistent among one another.

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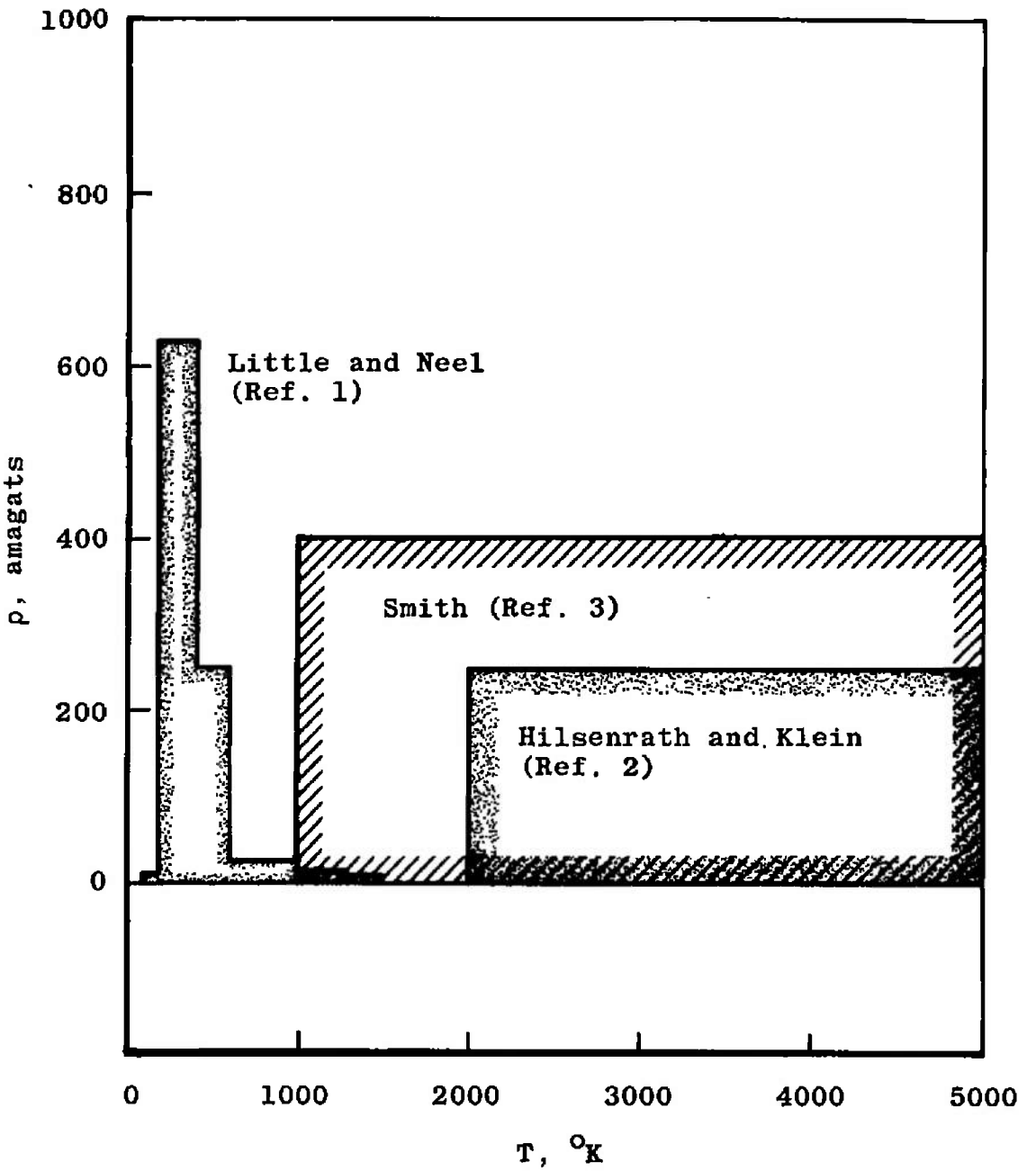

Fig. 1 Thermodynamic Domain of Nitrogen, with Density and Temperature as Variables, Showing Area Covered by Previously Published Tables

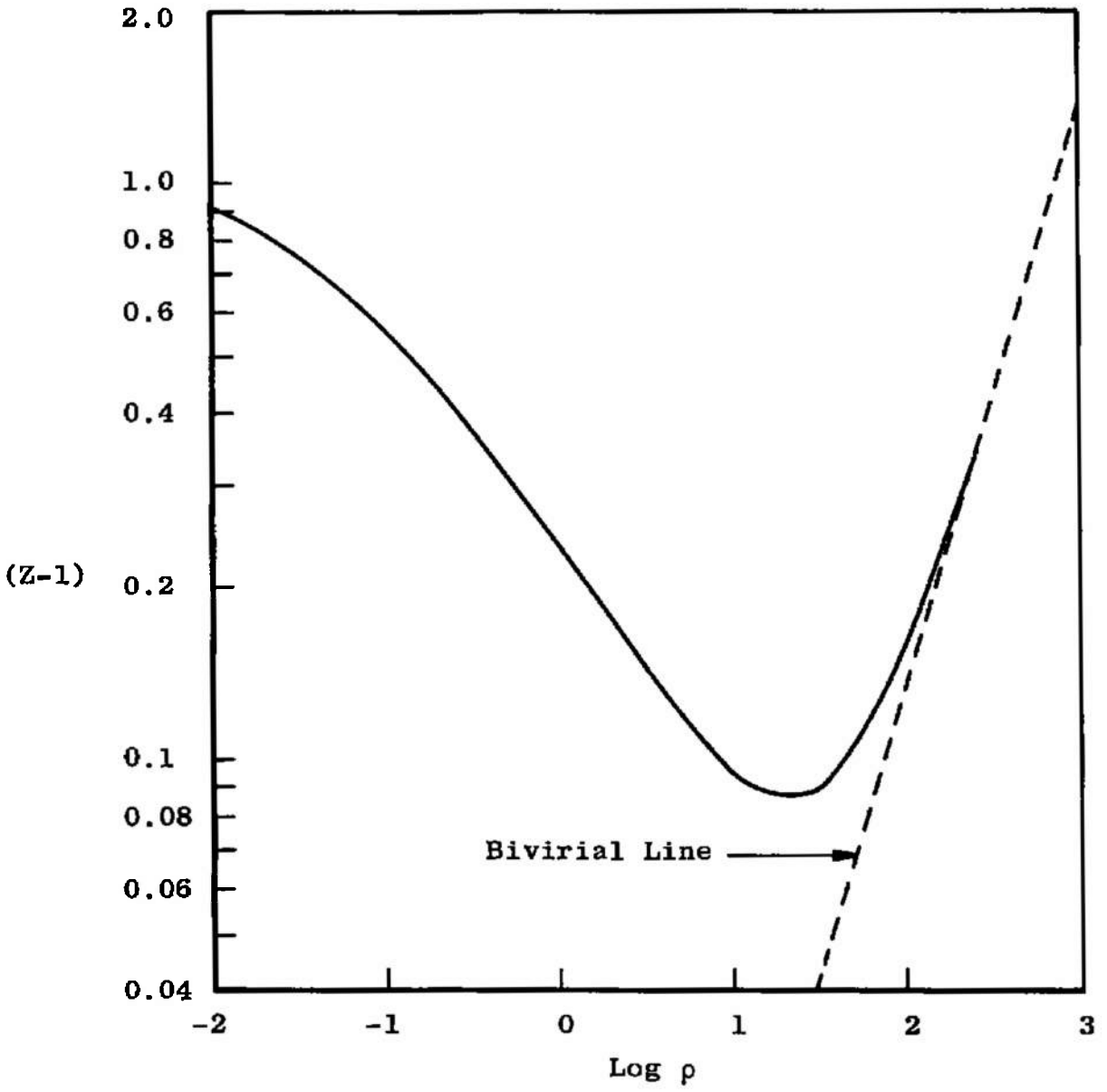

Fig. 2 Plot of (Z–1) for Nitrogen at 8000°K – Data from Ref. 2

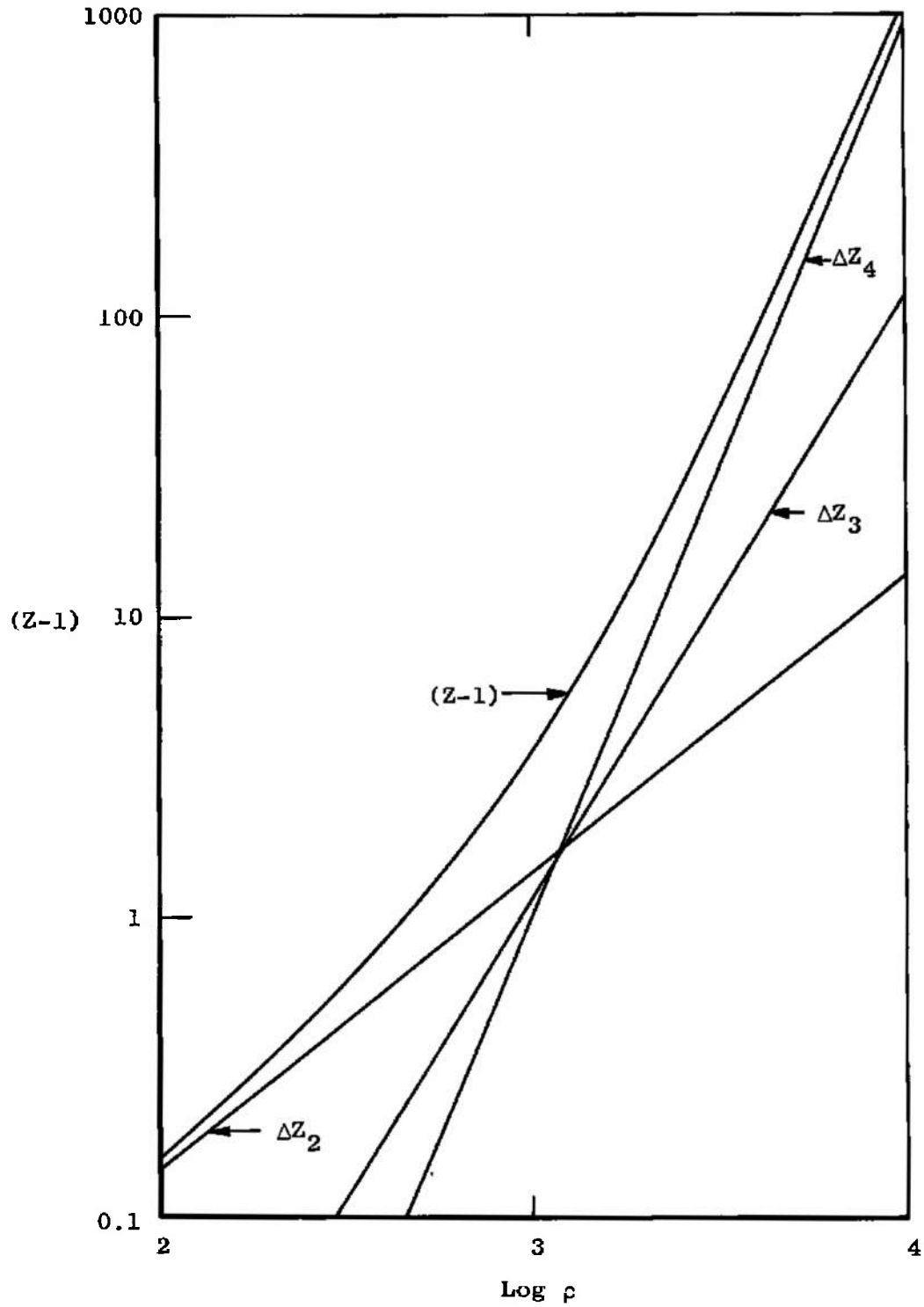

Fig. 3 Plot of Second, Third, and Fourth Virial Lines for Nitrogen at 3000°K – Data from Ref. 7

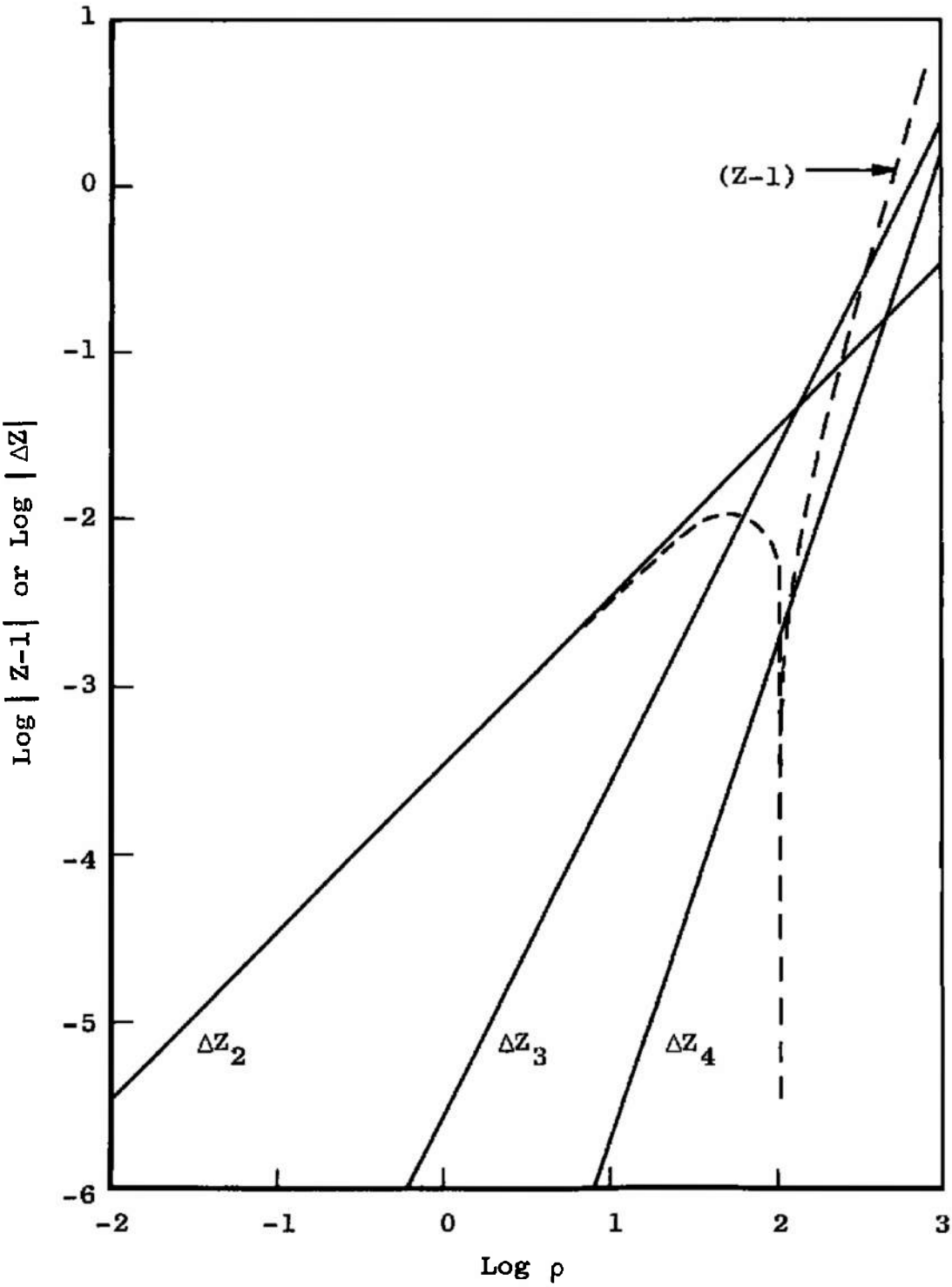

Fig. 4 Logarithmic Plot of Absolute Values of | Z − 1 | and Second, Third, and Fourth Virial Lines for Air at 25°C – Data from Ref. 10

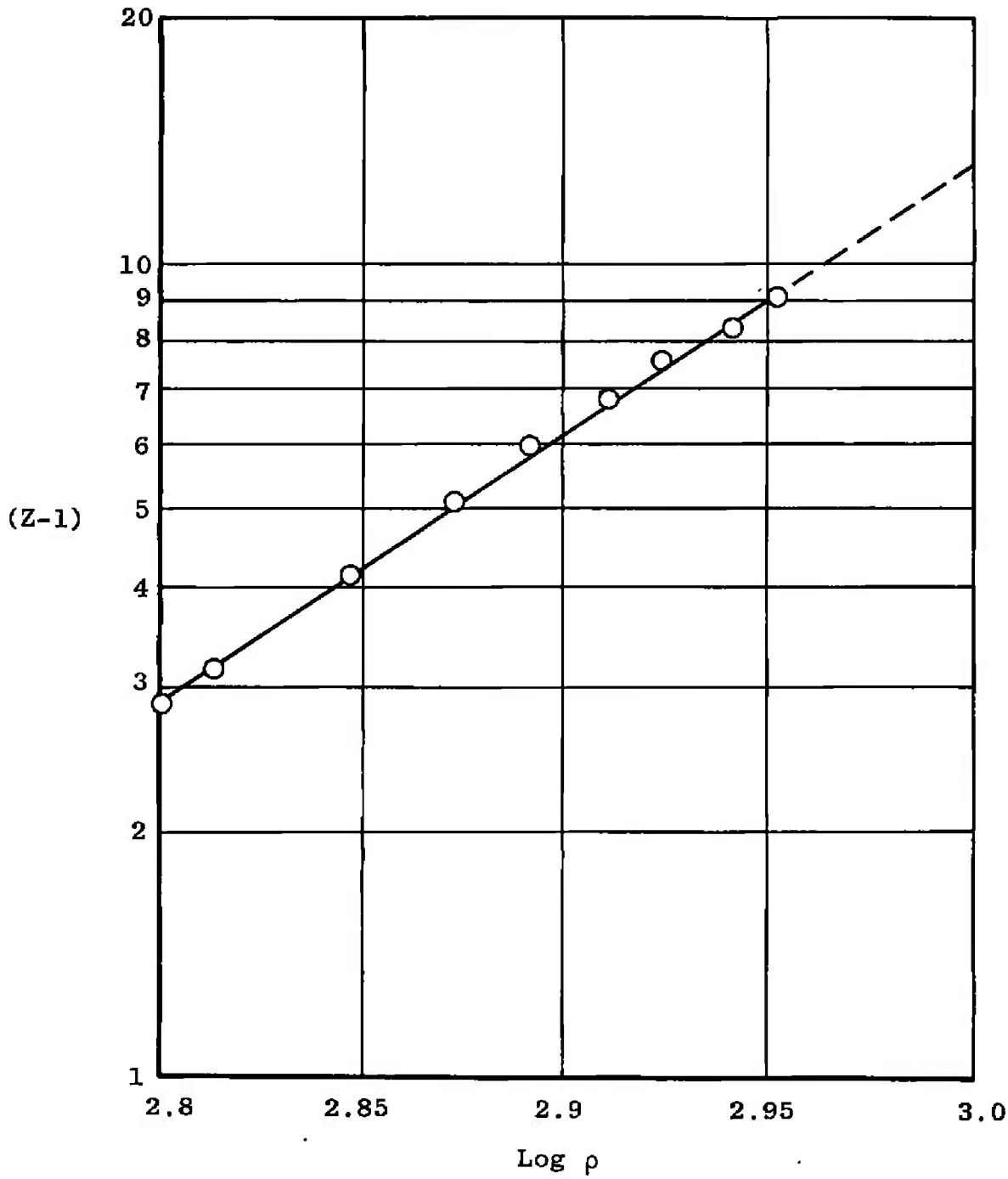

Fig. 5 Plot of (Z – 1) for Nitrogen at 300°K – Data from Ref. 1

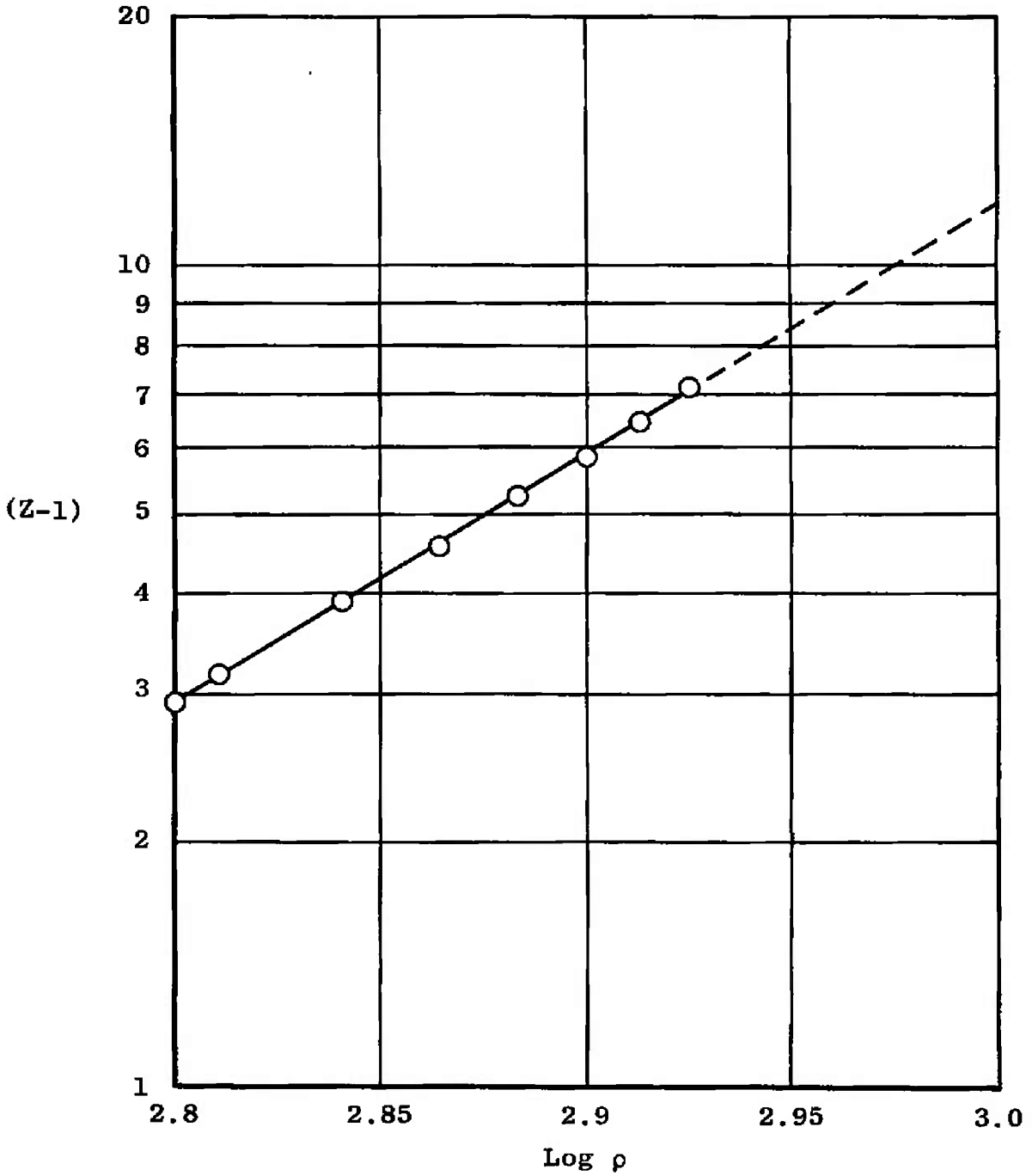

Fig. 6 Plot of (Z – 1) for Nitrogen at 400°K – Data from Ref. 1

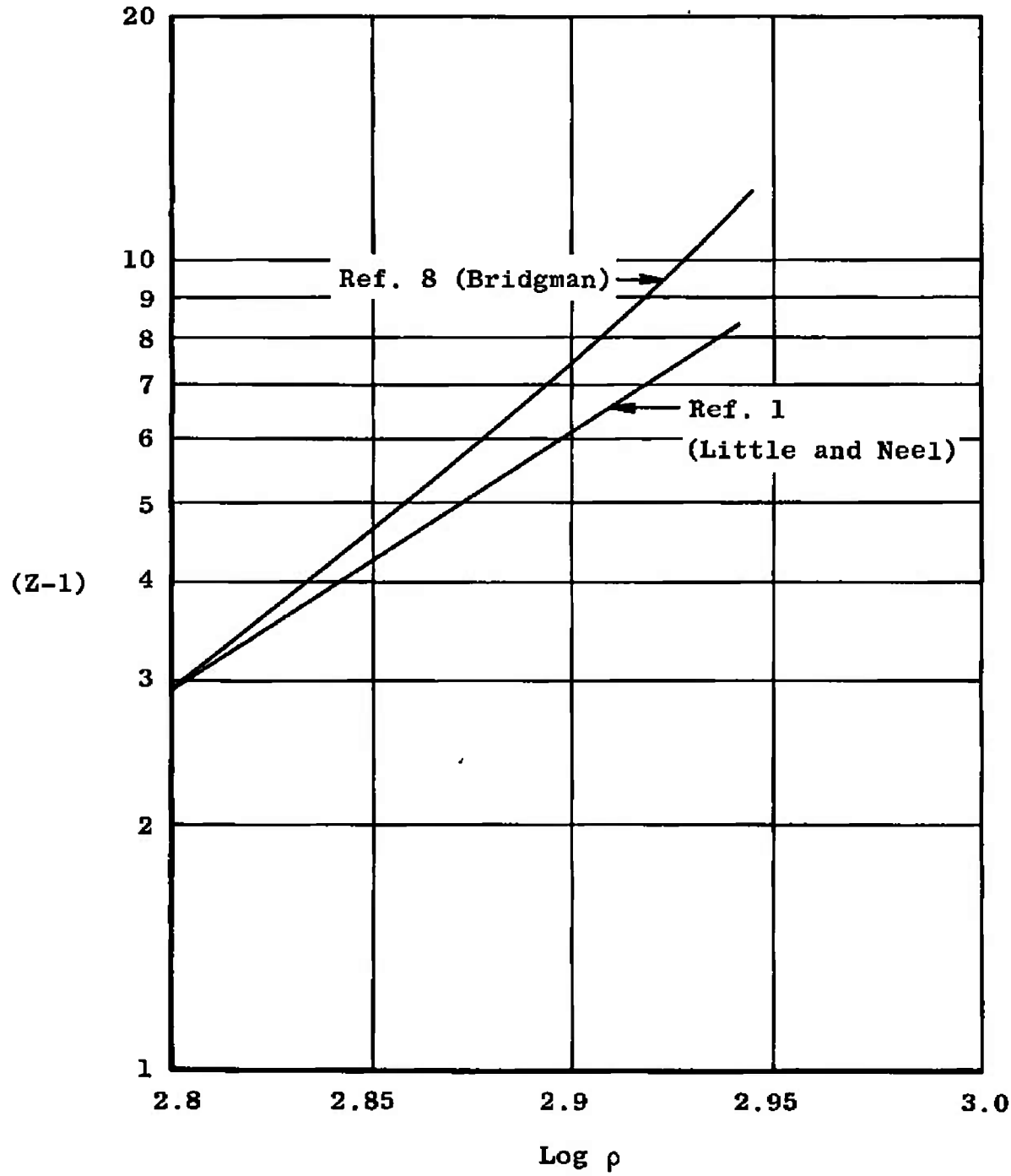

Fig. 7 Plot of (Z−1) for Nitrogen at 338°K (Data from Ref. 8) and at 340°K (Data from Ref. 1)

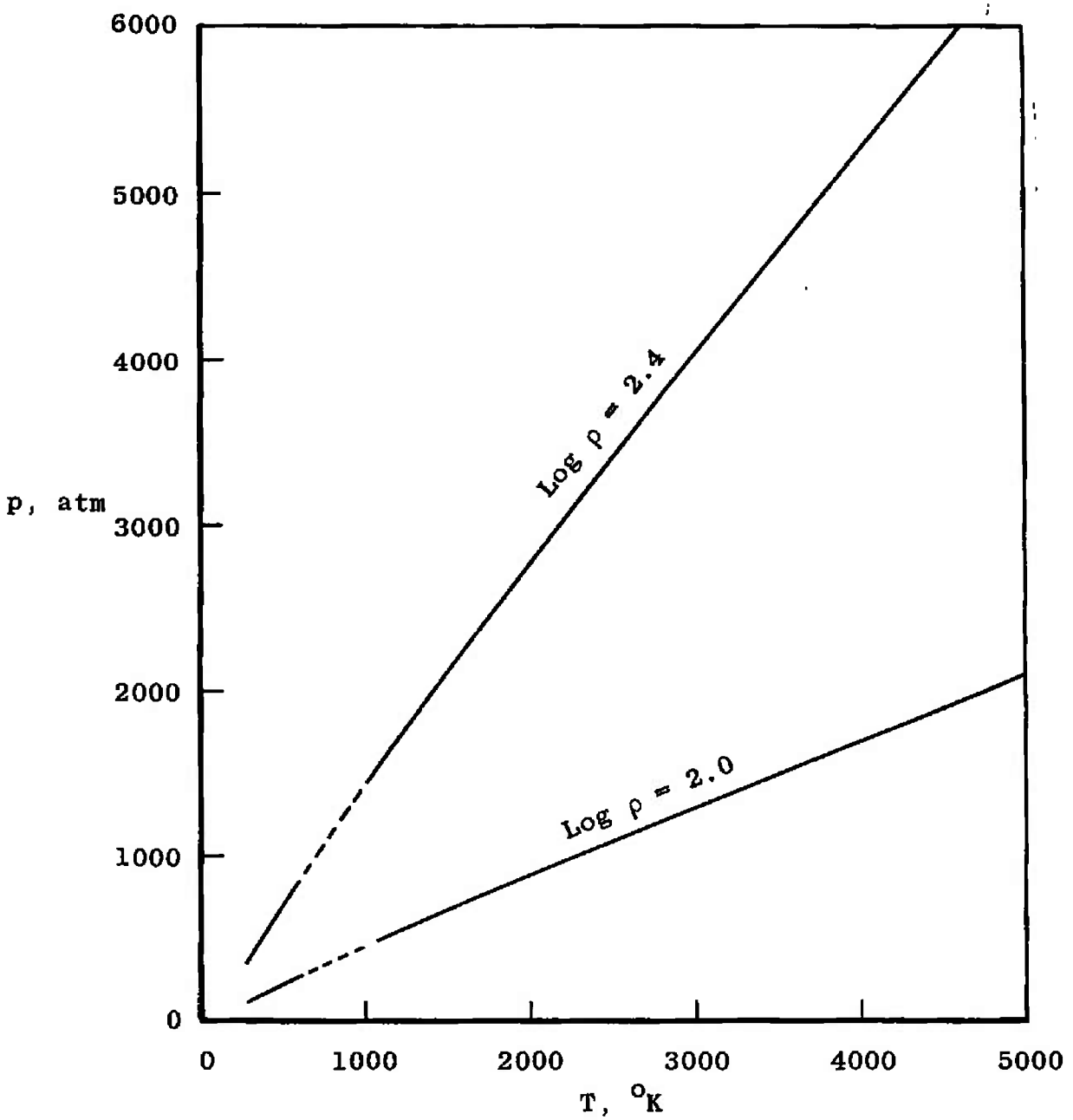

Fig. 8 Pressure-Temperature Lines for Nitrogen at Log ρ = 2.0 and 2.4 – Data from Refs. 1 and 3

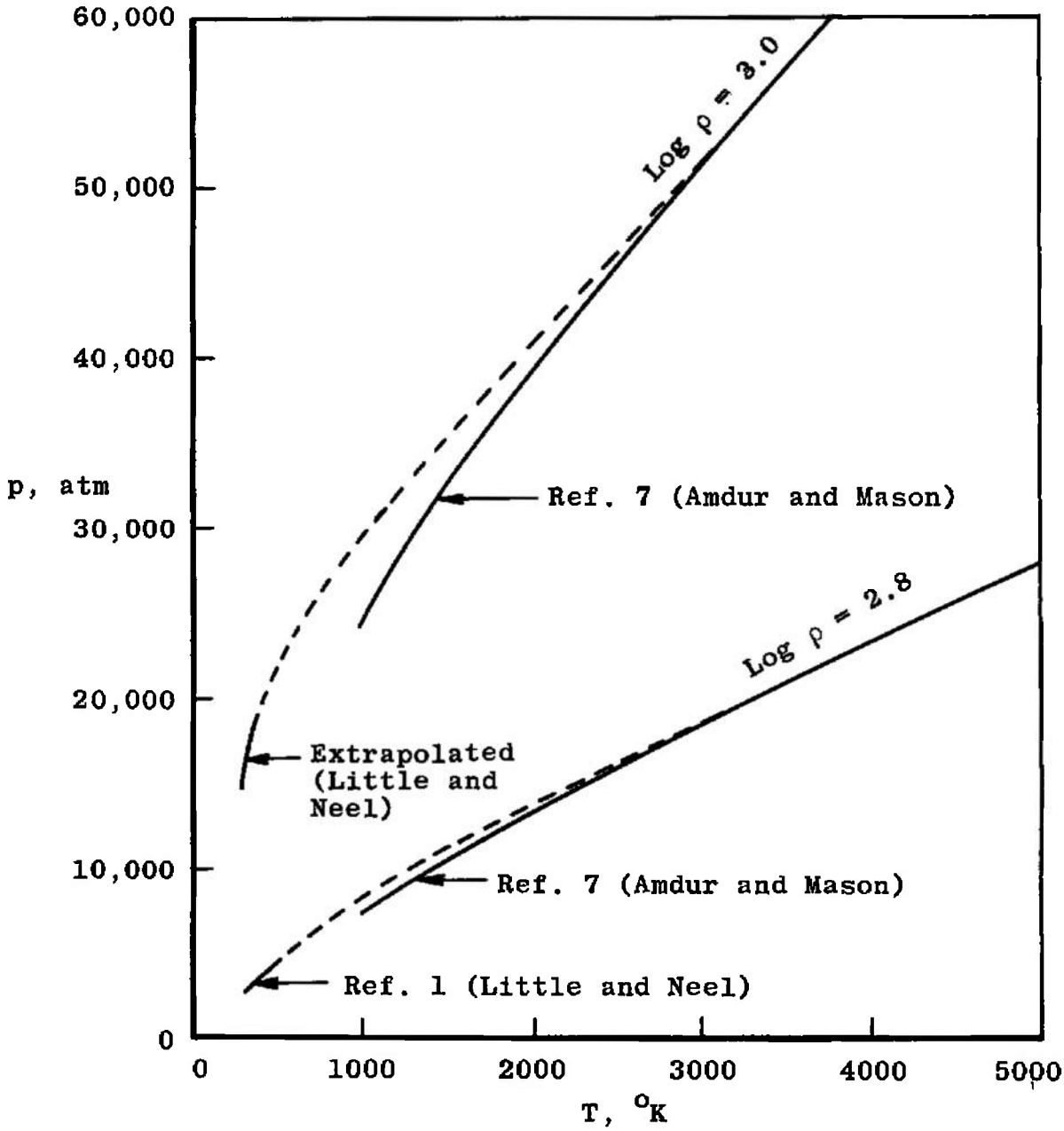

Fig. 9 Pressure-Temperature Lines for Nitrogen at Log ρ = 3.0 and 2.8 as Corrected by Empirical Formula (Sources of Data as Indicated)

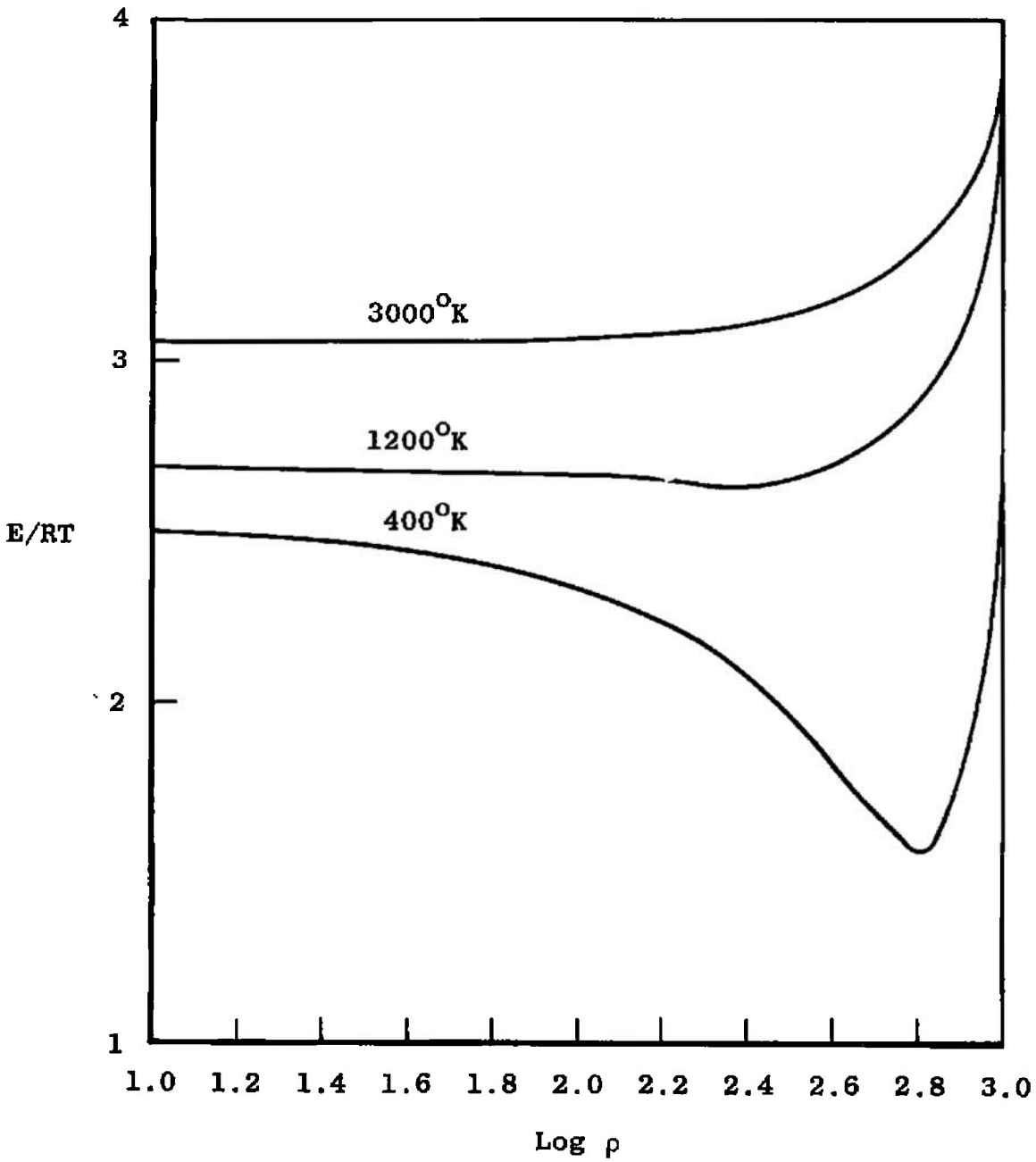

Fig. 10 Plot of E/RT versus Log ρ for Nitrogen at 400, 1200, and 3000°K – Data from Appendix I

TABLE I
NUMERICAL VALUES OF PARAMETERS IN EMPIRICAL EQUATION FOR PRESSURE-TEMPERATURE LINES AT CONSTANT DENSITY*

log ρ	a	b	c	e
3.0	18,391	10.9043	27,038	-0.005077
2.8	4020.5	4.7534	5083.7	-0.002020
2.6	973.62	2.3356	1479.7	-0.001445
2.4	262.24	1.2483	448.01	-0.001195
2.2	77.690	0.70638	150.46	-0.001130
2.0	24.655	0.41533	53.426	-0.001107
1.8	8.0750	0.25045	19.456	-0.001111
1.6	2.574	0.15353	7.2016	-0.001191
1.4	0.69300	0.09513	2.5711	-0.001345
1.2	0.05150	0.05935	0.83830	-0.001835
1.0	-0.14600	0.03719	0.92382	-0.010335

*$p = a + bT - c \exp(eT)$

TABLE II
SPOT COMPARISONS OF ENTRIES IN THE THERMODYNAMIC TABLES GIVEN IN APPENDIX I (G&B) WITH THE CORRESPONDING ENTRIES IN THE TABLES OF LITTLE AND NEEL (L&N), HILSENRATH AND KLEIN (H&K), AND SMITH

T = 400°K				T = 1000°K			
log ρ = 1.2				log ρ = 1.2			
	Z	E/RT	S/R		Z	E/RT	S/R
G&B	1.0078	2.4788	20.840	G&B	1.0215	2.6171	23.340
L&N	1.0077	2.4789	20.842	L&N	1.0235	2.6150	23.335
				Smith	1.0213	2.6189	23.341
log ρ = 1.8				log ρ = 1.8			
	Z	E/RT	S/R		Z	E/RT	S/R
G&B	1.0367	2.3931	19.348	G&B	1.0915	2.5992	21.874
L&N	1.0366	2.3965	19.354	Smith	1.0914	2.6116	21.886
log ρ = 2.4				log ρ = 2.4			
	Z	E/RT	S/R		Z	E/RT	S/R
G&B	1.3145	2.0588	17.465	G&B	1.4951	2.5468	20.122
L&N	1.3146	2.0778	17.488	Smith	1.4934	2.6055	20.174
log ρ = 2.8							
	Z	E/RT	S/R				
G&B	3.9582	1.5616	15.040				
L&N	3.9732	1.6617	15.128				

T = 3000°K				T = 5000°K			
log ρ = 1.2				log ρ = 1.2			
	Z	E/RT	S/R		Z	E/RT	S/R
G&B	1.0232	3.0642	26.901	G&B	1.0231	3.2926	28.746
H&K	1.0234	3.0656	26.902	H&K	1.0235	3.2682	28.720
Smith	1.0231	3.0440	26.872	Smith	1.0221	3.2056	28.632
log ρ = 1.8				log ρ = 1.8			
	Z	E/RT	S/R		Z	E/RT	S/R
G&B	1.0949	3.0683	25.453	G&B	1.0912	3.2963	27.300
H&K	1.0933	3.0684	25.453	H&K	1.0902	3.2642	27.267
Smith	1.0959	3.0465	25.422	Smith	1.0907	3.2168	27.195
log ρ = 2.4				log ρ = 2.4			
	Z	E/RT	S/R		Z	E/RT	S/R
G&B	1.4481	3.1062	23.802	G&B	1.4143	3.3263	25.659
H&K	1.3714	3.0798	23.805	H&K	1.3575	3.2868	25.640
Smith	1.4525	3.0742	23.752	Smith	1.4142	3.2749	25.577

APPENDIX I
TABLES OF THERMODYNAMIC PROPERTIES FOR NITROGEN

T= 300 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	.99999	2.49730	3.49729	22.92200	.04070	1.09825+00
.20	.99993	2.49528	3.49521	22.45948	.24067	1.74048+00
.40	.99985	2.49252	3.49237	21.99625	.44064	2.75829+00
.60	.99969	2.48878	3.48847	21.53209	.64057	4.37089+00
.80	.99932	2.48324	3.48256	21.06626	.84041	6.92484+00
1.00	.99886	2.47432	3.47318	20.59724	1.04021	1.09701+01
1.20	.99809	2.46063	3.45872	20.12373	1.23988	1.73732+01
1.40	.99736	2.43974	3.43709	19.64337	1.43955	2.75138+01
1.60	.99711	2.40709	3.40419	19.15153	1.63945	4.35963+01
1.80	.99963	2.35657	3.35620	18.64140	1.84055	6.92708+01
2.00	1.01006	2.27788	3.28794	18.10052	2.04505	1.10930+02
2.20	1.04785	2.15551	3.20336	17.50598	2.26100	1.82390+02
2.40	1.17222	1.96761	3.13984	16.81277	2.50972	3.23385+02
2.60	1.63570	1.68075	3.31644	15.90321	2.85441	7.15171+02
2.80	3.85892	1.32273	5.18165	14.41504	3.42717	2.67405+03
3.00	14.35730	2.15946	16.51675	11.56303	4.19778	1.57681+04

T= 400 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00092	2.50560	3.50652	23.63800	.16604	1.46568+00
.20	1.00120	2.50428	3.50548	23.17568	.36616	2.32359+00
.40	1.00160	2.50245	3.50405	22.71269	.56634	3.68417+00
.60	1.00220	2.49976	3.50196	22.24863	.76660	5.84252+00
.80	1.00330	2.49540	3.49870	21.78250	.96707	9.26979+00
1.00	1.00496	2.48906	3.49402	21.31378	1.16779	1.47160+01
1.20	1.00779	2.47879	3.48658	20.84011	1.36901	2.33889+01
1.40	1.01252	2.46116	3.47428	20.35798	1.57104	3.72426+01
1.60	1.02090	2.43499	3.45589	19.86320	1.77463	5.95155+01
1.80	1.03666	2.39306	3.42972	19.34785	1.98128	9.57811+01
2.00	1.06860	2.32691	3.39552	18.79792	2.19446	1.56480+02
2.20	1.13959	2.22232	3.36191	18.18709	2.42239	2.64478+02
2.40	1.31450	2.05877	3.37328	17.46512	2.68440	4.83504+02
2.60	1.84881	1.81104	3.65985	16.51322	3.03254	1.07780+03
2.80	3.95820	1.56158	5.51979	15.03991	3.56314	3.65713+03
3.00	13.11389	2.52211	15.63600	12.57004	4.28337	1.92030+04

T= 500 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00127	2.51360	3.51487	24.19600	.26311	1.83278+00
.20	1.00170	2.51319	3.51488	23.73440	.46329	2.90596+00
.40	1.00240	2.51219	3.51459	23.27194	.66359	4.60882+00
.60	1.00350	2.51045	3.51395	22.80836	.86407	7.31257+00
.80	1.00540	2.50753	3.51292	22.34288	1.06489	1.16115+01
1.00	1.00767	2.50383	3.51151	21.87573	1.26587	1.84446+01
1.20	1.01313	2.49737	3.51051	21.40408	1.46822	2.93914+01
1.40	1.02102	2.48553	3.50655	20.92398	1.67159	4.69451+01
1.60	1.03430	2.46691	3.50121	20.43238	1.87720	7.53703+01
1.80	1.05754	2.43774	3.49528	19.92208	2.08685	1.22138+02
2.00	1.10143	2.39230	3.49373	19.38064	2.30451	2.01609+02
2.20	1.19043	2.32218	3.51261	18.78529	2.53826	3.45350+02
2.40	1.39121	2.21722	3.60843	18.09283	2.80595	6.39661+02
2.60	1.95286	2.07267	4.02553	17.20193	3.15323	1.42308+03
2.80	3.93651	1.99488	5.93140	15.86626	3.65766	4.54632+03
3.00	11.85846	3.05776	14.91622	13.72470	4.33658	2.17060+04

T= 600 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00128	2.52170	3.52298	24.65500	.34229	2.19933+00
.20	1.00188	2.52159	3.52348	24.19367	.54255	3.48779+00
.40	1.00290	2.52101	3.52391	23.73147	.74299	5.53337+00
.60	1.00430	2.51965	3.52395	23.26797	.94360	8.78213+00
.80	1.00660	2.51750	3.52410	22.80280	1.14459	1.39505+01
1.00	1.00920	2.51474	3.52394	22.33598	1.34571	2.21672+01
1.20	1.01638	2.50962	3.52600	21.86461	1.54879	3.53826+01
1.40	1.02626	2.50024	3.52660	21.38514	1.75299	5.66226+01
1.60	1.04259	2.48557	3.52816	20.89433	1.95985	9.11696+01
1.80	1.07046	2.46235	3.53281	20.38516	2.17131	1.48358+02
2.00	1.12160	2.42611	3.54771	19.84543	2.39157	2.46360+02
2.20	1.22118	2.37046	3.59164	19.25296	2.62851	4.25119+02
2.40	1.43597	2.28821	3.72418	18.56592	2.89888	7.92282+02
2.60	2.00503	2.18289	4.18792	17.69101	3.24386	1.75332+03
2.80	3.86792	2.18078	6.04870	16.42328	3.72921	5.36056+03
3.00	10.76612	3.30248	14.06859	14.54026	4.37379	2.36478+04

T= 700 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00129	2.52950	3.53079	25.04600	.40924	2.56590+00
.20	1.00196	2.52938	3.53133	24.58463	.60953	4.06940+00
.40	1.00308	2.52914	3.53222	24.12273	.81002	6.45684+00
.60	1.00480	2.52847	3.53327	23.65977	1.01076	1.02509+01
.80	1.00730	2.52683	3.53413	23.19482	1.21184	1.62870+01
1.00	1.01021	2.52450	3.53472	22.72807	1.41309	2.58875+01
1.20	1.01846	2.52060	3.53906	22.25722	1.61662	4.13638+01
1.40	1.02968	2.51351	3.54319	21.77868	1.82138	6.62796+01
1.60	1.04802	2.50212	3.55015	21.28925	2.02905	1.06918+02
1.80	1.07893	2.48421	3.56314	20.78224	2.24168	1.74454+02
2.00	1.13469	2.45649	3.59118	20.24613	2.46356	2.90777+02
2.20	1.24074	2.41479	3.65552	19.66016	2.70236	5.03918+02
2.40	1.46309	2.35577	3.81885	18.98556	2.97395	9.41781+02
2.60	2.02954	2.29126	4.32080	18.13859	3.31608	2.07052+03
2.80	3.78055	2.35697	6.13751	16.94382	3.78624	6.11280+03
3.00	9.85280	3.49264	13.34544	15.24926	4.40224	2.52488+04

T= 800 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00130	2.56440	3.56570	25.48900	.46724	2.93251+00
.20	1.00201	2.56431	3.56632	25.02765	.66754	4.65093+00
.40	1.00319	2.56404	3.56723	24.56568	.86806	7.38006+00
.60	1.00502	2.56365	3.56867	24.10294	1.06885	1.17179+01
.80	1.00793	2.56249	3.57042	23.63827	1.27010	1.86252+01
1.00	1.01094	2.56046	3.57140	23.17150	1.47140	2.96074+01
1.20	1.01585	2.55729	3.57715	22.70092	1.67521	4.73380+01
1.40	1.03200	2.55173	3.58373	22.22306	1.88035	7.59189+01
1.60	1.05172	2.54271	3.59443	21.73464	2.08857	1.22622+02
1.80	1.08469	2.52850	3.61319	21.22919	2.30198	2.00438+02
2.00	1.14347	2.50666	3.65014	20.69565	2.52490	3.34888+02
2.20	1.25353	2.47445	3.72798	20.11424	2.76481	5.81849+02
2.40	1.47963	2.43089	3.91052	19.44824	3.03683	1.08850+03
2.60	2.03827	2.39316	4.43143	18.62121	3.37594	2.37651+03
2.80	3.68747	2.50331	6.19078	17.48272	3.83340	6.81397+03
3.00	9.09960	3.62685	12.72645	15.92697	4.42570	2.66502+04

T= 900 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00131	2.59280	3.59411	25.82100	.51839	3.29906+00
.20	1.00205	2.59269	3.59474	25.35962	.71872	5.23263+00
.40	1.00326	2.59250	3.59576	24.89771	.91924	8.30309+00
.60	1.00516	2.59213	3.59729	24.43493	1.12006	1.31844+01
.80	1.00821	2.59155	3.59977	23.97075	1.32138	2.09595+01
1.00	1.01150	2.59020	3.60170	23.50447	1.52279	3.33265+01
1.20	1.02081	2.58755	3.60836	23.03406	1.72677	5.33053+01
1.40	1.03361	2.58321	3.61682	22.55685	1.93218	8.55421+01
1.60	1.05429	2.57608	3.63037	22.06938	2.14078	1.38287+02
1.80	1.08868	2.56490	3.65358	21.56546	2.35473	2.26324+02
2.00	1.14949	2.54786	3.69735	21.03444	2.57833	3.78730+02
2.20	1.26199	2.52347	3.78546	20.45752	2.81888	6.58992+02
2.40	1.48953	2.49276	3.98229	19.80002	3.09088	1.23276+03
2.60	2.03764	2.47712	4.51476	18.99197	3.42695	2.67270+03
2.80	3.59523	2.62114	6.21637	17.90239	3.87355	7.47395+03
3.00	8.47529	3.71598	12.19127	16.44881	4.44598	2.79242+04

T= 1000 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00132	2.62162	3.62294	26.12700	.56416	3.66573+00
.20	1.00209	2.62151	3.62360	25.66561	.76449	5.81420+00
.40	1.00331	2.62133	3.62464	25.20368	.96502	9.22614+00
.60	1.00526	2.62100	3.62627	24.74092	1.16586	1.46508+01
.80	1.00837	2.62057	3.62894	24.27683	1.36720	2.32916+01
1.00	1.01195	2.61936	3.63131	23.81055	1.56874	3.70459+01
1.20	1.02148	2.61714	3.63863	23.34032	1.77282	5.92680+01
1.40	1.03475	2.61373	3.64848	22.86363	1.97842	9.51525+01
1.60	1.05610	2.60808	3.66418	22.37696	2.18729	1.53918+02
1.80	1.09150	2.59924	3.69074	21.87434	2.40161	2.52122+02
2.00	1.15363	2.58596	3.73959	21.34548	2.62565	4.22328+02
2.20	1.26756	2.56764	3.83519	20.77239	2.86655	7.35445+02
2.40	1.49507	2.54684	4.04191	20.12210	3.13825	1.37483+03
2.60	2.03133	2.54799	4.57932	19.33009	3.47136	2.96047+03
2.80	3.50700	2.71604	6.22304	18.28097	3.90852	8.10065+03
3.00	7.95613	3.77318	11.72931	16.90313	4.46428	2.91259+04

T= 1100 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00133	2.65194	3.65327	26.40860	.60555	4.03227+00
.20	1.00212	2.65183	3.65395	25.94720	.80589	6.39573+00
.40	1.00336	2.65167	3.65503	25.48528	1.00643	1.01492+01
.60	1.00534	2.65140	3.65673	25.02253	1.20729	1.61172+01
.80	1.00849	2.65105	3.65954	24.55849	1.40865	2.56242+01
1.00	1.01231	2.64996	3.66227	24.09223	1.61029	4.07652+01
1.20	1.02197	2.64809	3.67006	23.62215	1.81441	6.52244+01
1.40	1.03556	2.64543	3.68099	23.14593	2.02015	1.04749+02
1.60	1.05740	2.64100	3.69840	22.66000	2.22921	1.69516+02
1.80	1.09350	2.63411	3.72761	22.15857	2.44379	2.77837+02
2.00	1.15650	2.62395	3.78045	21.63171	2.66812	4.65715+02
2.20	1.27116	2.61068	3.88184	21.06218	2.90918	8.11297+02
2.40	1.49771	2.59812	4.09583	20.41853	3.18040	1.51496+03
2.60	2.02165	2.61291	4.63456	19.64093	3.51068	3.24101+03
2.80	3.42373	2.79849	6.22222	18.62625	3.93948	8.69921+03
3.00	7.52044	3.81369	11.33414	17.30528	4.48122	3.02845+04

T= 1200 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00135	2.68218	3.68353	26.67090	.64335	4.39896+00
.20	1.00214	2.68207	3.68421	26.20949	.84369	6.97734+00
.40	1.00340	2.68192	3.68531	25.74756	1.04424	1.10724+01
.60	1.00539	2.68164	3.68704	25.28479	1.24510	1.75833+01
.80	1.00858	2.68130	3.68988	24.82073	1.44647	2.79557+01
1.00	1.01261	2.68028	3.69289	24.35444	1.64821	4.44846+01
1.20	1.02231	2.67869	3.70100	23.88449	1.85235	7.11787+01
1.40	1.03614	2.67662	3.71276	23.40866	2.05818	1.14335+02
1.60	1.05832	2.67320	3.73151	22.92339	2.26738	1.85089+02
1.80	1.09490	2.66791	3.76280	22.42304	2.48214	3.03487+02
2.00	1.15843	2.66031	3.81874	21.89798	2.70663	5.08897+02
2.20	1.27333	2.65120	3.92453	21.33163	2.94771	8.86564+02
2.40	1.49830	2.64537	4.14367	20.69392	3.21836	1.65333+03
2.60	2.00992	2.67100	4.68093	19.92895	3.54594	3.51512+03
2.80	3.34634	2.86883	6.21517	18.94323	3.96733	9.27534+03
3.00	7.15105	3.84067	10.99171	17.66537	4.49713	3.14145+04

T= 1300 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00136	2.71180	3.71316	26.91640	.67812	4.76563+00
.20	1.00216	2.71169	3.71385	26.45498	.87846	7.55892+00
.40	1.00343	2.71154	3.71497	25.99304	1.07901	1.19953+01
.60	1.00545	2.71126	3.71671	25.53024	1.27989	1.90498+01
.80	1.00866	2.71090	3.71956	25.06614	1.48127	3.02880+01
1.00	1.01287	2.70991	3.72278	24.59981	1.68308	4.82037+01
1.20	1.02256	2.70854	3.73111	24.12996	1.88722	7.71294+01
1.40	1.03655	2.70695	3.74350	23.65445	2.09312	1.23914+02
1.60	1.05896	2.70432	3.76328	23.16973	2.30241	2.00637+02
1.80	1.09587	2.70032	3.79620	22.67030	2.51729	3.29071+02
2.00	1.15971	2.69480	3.85450	22.14679	2.74187	5.51912+02
2.20	1.27453	2.68902	3.96355	21.58318	2.98288	9.61347+02
2.40	1.49754	2.68854	4.18608	20.95058	3.25290	1.79019+03
2.60	1.99713	2.72260	4.71973	20.19642	3.57793	3.78382+03
2.80	3.27458	2.92836	6.20294	19.23482	3.99268	9.83286+03
3.00	6.83518	3.85684	10.69202	17.98968	4.51228	3.25297+04

T= 1400 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00138	2.74045	3.74183	27.14710	.71031	5.13228+00
.20	1.00218	2.74035	3.74253	26.68568	.91066	8.14067+00
.40	1.00346	2.74019	3.74365	26.22372	1.11121	1.29184+01
.60	1.00550	2.73997	3.74547	25.76097	1.31209	2.05159+01
.80	1.00874	2.73967	3.74841	25.29689	1.51349	3.26205+01
1.00	1.01309	2.73873	3.75182	24.83054	1.71536	5.19230+01
1.20	1.02275	2.73754	3.76029	24.36078	1.91948	8.30768+01
1.40	1.03684	2.73633	3.77317	23.88555	2.12542	1.33481+02
1.60	1.05941	2.73438	3.79379	23.40134	2.33478	2.16162+02
1.80	1.09654	2.73148	3.82802	22.90275	2.54973	3.54593+02
2.00	1.16049	2.72773	3.88822	22.38067	2.77435	5.94771+02
2.20	1.27501	2.72478	3.99979	21.81957	3.01522	1.03567+03
2.40	1.49583	2.72883	4.22466	21.19163	3.28459	1.92571+03
2.60	1.98385	2.76973	4.75358	20.44711	3.60722	4.04781+03
2.80	3.20854	2.98047	6.18901	19.50591	4.01602	1.03758+04
3.00	6.56271	3.86694	10.42965	18.28600	4.52679	3.36349+04

T= 1500 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00139	2.76792	3.76931	27.36460	.74028	5.49895+00
.20	1.00220	2.76783	3.77003	26.90318	.94063	8.72228+00
.40	1.00349	2.76768	3.77117	26.44122	1.14119	1.38417+01
.60	1.00553	2.76746	3.77300	25.97846	1.34207	2.19821+01
.80	1.00881	2.76718	3.77599	25.51438	1.54349	3.49534+01
1.00	1.01328	2.76630	3.77958	25.04802	1.74540	5.56417+01
1.20	1.02288	2.76526	3.78814	24.57833	1.94950	8.90225+01
1.40	1.03704	2.76436	3.80141	24.10335	2.15547	1.43044+02
1.60	1.05971	2.76297	3.82268	23.61958	2.36486	2.31665+02
1.80	1.09697	2.76098	3.85795	23.12174	2.57987	3.80076+02
2.00	1.16092	2.75871	3.91963	22.60093	2.80448	6.37500+02
2.20	1.27497	2.75812	4.03309	22.04207	3.04517	1.10961+03
2.40	1.49349	2.76589	4.25938	21.41826	3.31388	2.06006+03
2.60	1.97049	2.81221	4.78270	20.68216	3.63425	4.30775+03
2.80	3.14773	3.02548	6.17321	19.75812	4.03767	1.09061+04
3.00	6.32537	3.87169	10.19706	18.55771	4.54076	3.47344+04

T= 1600 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00140	2.79411	3.79551	27.57020	.76831	5.86557+00
.20	1.00222	2.79402	3.79623	27.10877	.96866	9.30379+00
.40	1.00352	2.79391	3.79743	26.64685	1.16923	1.47649+01
.60	1.00558	2.79351	3.79910	26.18388	1.37012	2.34488+01
.80	1.00887	2.79305	3.80193	25.71961	1.57154	3.72855+01
1.00	1.01344	2.79225	3.80569	25.25328	1.77350	5.93608+01
1.20	1.02298	2.79132	3.81430	24.78364	1.97757	9.49664+01
1.40	1.03718	2.79069	3.82787	24.30886	2.18356	1.52602+02
1.60	1.05990	2.78976	3.84966	23.82549	2.39297	2.47155+02
1.80	1.09722	2.78855	3.88576	23.32832	2.60799	4.05499+02
2.00	1.16109	2.78752	3.94861	22.80865	2.83257	6.80096+02
2.20	1.27455	2.78892	4.06347	22.25180	3.07306	1.18321+03
2.40	1.49070	2.79978	4.29049	21.63169	3.34109	2.19326+03
2.60	1.95725	2.85038	4.80763	20.90300	3.65935	4.56405+03
2.80	3.09181	3.06430	6.15611	19.99340	4.05792	1.14267+04
3.00	6.11708	3.87231	9.98939	18.80818	4.55425	3.58303+04

T= 1700 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00141	2.81899	3.82040	27.76530	.79464	6.23218+00
.20	1.00223	2.81889	3.82112	27.30386	.99500	9.88553+00
.40	1.00354	2.81881	3.82235	26.84196	1.19557	1.56881+01
.60	1.00568	2.81830	3.82398	26.37886	1.39649	2.49167+01
.80	1.00893	2.81774	3.82667	25.91445	1.59789	3.96178+01
1.00	1.01359	2.81701	3.83060	25.44813	1.79989	6.30798+01
1.20	1.02305	2.81618	3.83922	24.97853	2.00393	1.00909+02
1.40	1.03726	2.81575	3.85301	24.50394	2.20992	1.62151+02
1.60	1.06001	2.81521	3.87522	24.02090	2.41934	2.62627+02
1.80	1.09733	2.81464	3.91198	23.52433	2.63437	4.30894+02
2.00	1.16105	2.81466	3.97571	23.00567	2.85888	7.22570+02
2.20	1.27387	2.81770	4.09157	22.45060	3.09916	1.25649+03
2.40	1.48764	2.83110	4.31875	21.83376	3.36653	2.32557+03
2.60	1.94435	2.88499	4.82934	21.11154	3.68281	4.81737+03
2.80	3.04027	3.09807	6.13834	20.21407	4.07694	1.19382+04
3.00	5.93296	3.86954	9.80290	19.04062	4.56730	3.69233+04

T= 1800 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00142	2.84256	3.84398	27.95060	.81947	6.59888+00
.20	1.00224	2.84243	3.84467	27.48912	1.01983	1.04672+01
.40	1.00356	2.84232	3.84588	27.02719	1.22040	1.66112+01
.60	1.00575	2.84212	3.84787	26.56437	1.42135	2.63846+01
.80	1.00897	2.84188	3.85085	26.10025	1.62274	4.19508+01
1.00	1.01372	2.84114	3.85486	25.63390	1.82477	6.67990+01
1.20	1.02310	2.84040	3.86350	25.16435	2.02877	1.06849+02
1.40	1.03730	2.84015	3.87745	24.68990	2.23476	1.71696+02
1.60	1.06005	2.83994	3.89999	24.20718	2.44418	2.78087+02
1.80	1.09735	2.83992	3.93727	23.71113	2.65920	4.56247+02
2.00	1.16087	2.84082	4.00169	23.19339	2.88364	7.64962+02
2.20	1.27299	2.84526	4.11825	22.63993	3.12368	1.32947+03
2.40	1.48442	2.86076	4.34517	22.02602	3.39041	2.45703+03
2.60	1.93187	2.91719	4.84906	21.30949	3.70483	5.06792+03
2.80	2.99294	3.12839	6.12132	20.42226	4.09495	1.24437+04
3.00	5.76914	3.86638	9.63551	19.25807	4.57997	3.80163+04

T= 1900 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00144	2.86487	3.86631	28.12720	.84296	6.96562+00
.20	1.00225	2.86473	3.86698	27.66571	1.04331	1.10487+01
.40	1.00357	2.86458	3.86816	27.20373	1.24389	1.75344+01
.60	1.00573	2.86473	3.87046	26.74125	1.44482	2.78497+01
.80	1.00901	2.86484	3.87385	26.27749	1.64623	4.42823+01
1.00	1.01384	2.86410	3.87793	25.81109	1.84831	7.05196+01
1.20	1.02314	2.86344	3.88657	25.34158	2.05227	1.12790+02
1.40	1.03732	2.86332	3.90064	24.86726	2.25825	1.81238+02
1.60	1.06005	2.86339	3.92344	24.38487	2.46766	2.93535+02
1.80	1.09729	2.86383	3.96113	23.88924	2.68266	4.81571+02
2.00	1.16058	2.86548	4.02606	23.37231	2.90701	8.07254+02
2.20	1.27198	2.87108	4.14306	22.82028	3.14682	1.40223+03
2.40	1.48110	2.88829	4.36939	22.20897	3.41292	2.58774+03
2.60	1.91987	2.94659	4.86647	21.49742	3.72561	5.31631+03
2.80	2.94930	3.15507	6.10437	20.61882	4.11206	1.29437+04
3.00	5.62238	3.86128	9.48366	19.46191	4.59226	3.91075+04

T= 2000 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	2.89724	3.89872	28.30880	.86526	7.33263+00
.20	1.00226	2.89716	3.89942	27.84736	1.06559	1.16303+01
.40	1.00359	2.89704	3.90062	27.38540	1.26617	1.84574+01
.60	1.00570	2.89709	3.90278	26.92283	1.46708	2.93143+01
.80	1.00905	2.89712	3.90617	26.45900	1.66852	4.66144+01
1.00	1.01394	2.89644	3.91038	25.99262	1.87063	7.42386+01
1.20	1.02316	2.89583	3.91899	25.52313	2.07456	1.18730+02
1.40	1.03732	2.89584	3.93315	25.04893	2.28052	1.90774+02
1.60	1.06000	2.89613	3.95614	24.56672	2.48992	3.08973+02
1.80	1.09718	2.89697	3.99414	24.07157	2.70489	5.06862+02
2.00	1.16021	2.89925	4.05946	23.55538	2.92915	8.49474+02
2.20	1.27087	2.90581	4.17668	23.00463	3.16871	1.47472+03
2.40	1.47776	2.92442	4.40218	22.39563	3.43422	2.71782+03
2.60	1.90839	2.98406	4.89245	21.68844	3.74528	5.56263+03
2.80	2.90510	3.18916	6.09826	20.81706	4.12837	1.34391+04
3.00	5.49026	3.86559	9.35584	19.66582	4.60421	4.01985+04

T= 2100 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	2.91786	3.91934	28.47170	.88645	7.69928+00
.20	1.00227	2.91784	3.92011	28.01031	1.08679	1.22121+01
.40	1.00360	2.91776	3.92136	27.54839	1.28736	1.93803+01
.60	1.00570	2.91758	3.92328	27.08560	1.48827	3.07801+01
.80	1.00908	2.91739	3.92647	26.62153	1.68973	4.89474+01
1.00	1.01404	2.91679	3.93083	26.15520	1.89186	7.79579+01
1.20	1.02318	2.91623	3.93941	25.68573	2.09575	1.24667+02
1.40	1.03730	2.91633	3.95363	25.21163	2.30171	2.00313+02
1.60	1.05994	2.91681	3.97675	24.72962	2.51108	3.24399+02
1.80	1.09702	2.91797	4.01499	24.23485	2.72602	5.32133+02
2.00	1.15978	2.92079	4.08057	23.71931	2.95018	8.91620+02
2.20	1.26971	2.92815	4.19785	23.16970	3.18951	1.54707+03
2.40	1.47442	2.94788	4.42230	22.56277	3.45442	2.84721+03
2.60	1.89743	3.00841	4.90584	21.85940	3.76397	5.80724+03
2.80	2.87195	3.20967	6.08162	20.99410	4.14398	1.39309+04
3.00	5.37074	3.85825	9.22899	19.84733	4.61584	4.12895+04

T= 2200 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	2.93837	3.93985	28.62760	.90665	8.06585+00
.20	1.00228	2.93833	3.94061	28.16620	1.10699	1.27935+01
.40	1.00361	2.93828	3.94189	27.70430	1.30757	2.03035+01
.60	1.00573	2.93810	3.94382	27.24149	1.50849	3.22471+01
.80	1.00910	2.93791	3.94701	26.77742	1.70994	5.12791+01
1.00	1.01412	2.93735	3.95148	26.31110	1.91210	8.16770+01
1.20	1.02319	2.93683	3.96002	25.84164	2.11596	1.30605+02
1.40	1.03727	2.93701	3.97427	25.36763	2.32190	2.09846+02
1.60	1.05985	2.93765	3.99750	24.88581	2.53125	3.39821+02
1.80	1.09683	2.93908	4.03591	24.39137	2.74615	5.57378+02
2.00	1.15931	2.94234	4.10165	23.87642	2.97021	9.33706+02
2.20	1.26851	2.95037	4.21887	23.32783	3.20930	1.61920+03
2.40	1.47114	2.97101	4.44215	22.72274	3.47366	2.97619+03
2.60	1.88702	3.03208	4.91909	22.02275	3.78178	6.05034+03
2.80	2.83756	3.22922	6.06678	21.16260	4.15895	1.44195+04
3.00	5.26201	3.85169	9.11370	20.01929	4.62716	4.23799+04

T= 2300 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00149	2.95669	3.95818	28.77750	.92596	8.43257+00
.20	1.00228	2.95663	3.95891	28.31608	1.12630	1.33752+01
.40	1.00362	2.95658	3.96019	27.85417	1.32688	2.12266+01
.60	1.00574	2.95649	3.96223	27.39145	1.52780	3.37132+01
.80	1.00912	2.95641	3.96552	26.92748	1.72925	5.36105+01
1.00	1.01420	2.95587	3.97008	26.46117	1.93144	8.53965+01
1.20	1.02320	2.95538	3.97858	25.99171	2.13527	1.36543+02
1.40	1.03722	2.95562	3.99284	25.51777	2.34118	2.19371+02
1.60	1.05975	2.95640	4.01615	25.03612	2.55051	3.55230+02
1.80	1.09662	2.95806	4.05468	24.54198	2.76537	5.82599+02
2.00	1.15882	2.96169	4.12050	24.02754	2.98933	9.75731+02
2.20	1.26729	2.97026	4.23755	23.47988	3.22819	1.69118+03
2.40	1.46792	2.99162	4.45954	22.87643	3.49201	3.10463+03
2.60	1.87712	3.05292	4.93004	22.17940	3.79880	6.29216+03
2.80	2.80571	3.24576	6.05147	21.32362	4.17335	1.49056+04
3.00	5.16279	3.84381	9.00660	20.18302	4.63820	4.34710+04

T= 2400 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00149	2.97431	3.97580	28.92160	.94444	8.79914+00
.20	1.00228	2.97428	3.97657	28.46021	1.14479	1.39569+01
.40	1.00362	2.97424	3.97786	27.99831	1.34536	2.21493+01
.60	1.00575	2.97418	3.97993	27.53561	1.54628	3.51787+01
.80	1.00913	2.97414	3.98327	27.07168	1.74774	5.59423+01
1.00	1.01428	2.97364	3.98792	26.60538	1.94995	8.91148+01
1.20	1.02320	2.97318	3.99638	26.13594	2.15375	1.42479+02
1.40	1.03718	2.97347	4.01065	25.66206	2.35965	2.28902+02
1.60	1.05964	2.97436	4.03399	25.18055	2.56895	3.70638+02
1.80	1.09639	2.97622	4.07261	24.68669	2.78376	6.07799+02
2.00	1.15830	2.98016	4.13846	24.17272	3.00762	1.01770+03
2.20	1.26607	2.98918	4.25525	23.62588	3.24625	1.76299+03
2.40	1.46479	3.01107	4.47586	23.02390	3.50957	3.23273+03
2.60	1.86773	3.07235	4.94008	22.32944	3.81511	6.53296+03
2.80	2.77620	3.26073	6.03694	21.47731	4.18725	1.53904+04
3.00	5.07182	3.83596	8.90779	20.33883	4.64896	4.45615+04

T= 2500 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00149	2.99192	3.99341	29.06040	.96217	9.16579+00
.20	1.00229	2.99194	3.99422	28.59905	1.16252	1.45385+01
.40	1.00363	2.99191	3.99553	28.13716	1.36310	2.30728+01
.60	1.00575	2.99184	3.99760	27.67446	1.56402	3.66454+01
.80	1.00914	2.99182	4.00096	27.21054	1.76547	5.82734+01
1.00	1.01434	2.99136	4.00570	26.74427	1.96771	9.28346+01
1.20	1.02320	2.99093	4.01413	26.27484	2.17148	1.48416+02
1.40	1.03712	2.99126	4.02839	25.80101	2.37735	2.38424+02
1.60	1.05951	2.99224	4.05175	25.31963	2.58663	3.86038+02
1.80	1.09615	2.99426	4.09041	24.82600	2.80139	6.32980+02
2.00	1.15778	2.99845	4.15623	24.31246	3.02515	1.05962+03
2.20	1.26487	3.00783	4.27269	23.76635	3.26357	1.83472+03
2.40	1.46174	3.03012	4.49186	23.16567	3.52639	3.36039+03
2.60	1.85882	3.09114	4.94996	22.47346	3.83076	6.77267+03
2.80	2.74874	3.27500	6.02374	21.62439	4.20066	1.58730+04
3.00	4.98805	3.82878	8.81683	20.48752	4.65945	4.56510+04

T= 2600 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.00783	4.00931	29.19400	.97920	9.53235+00
.20	1.00229	3.00784	4.01013	28.73264	1.17955	1.51199+01
.40	1.00363	3.00782	4.01145	28.27077	1.38013	2.39955+01
.60	1.00576	3.00778	4.01354	27.80808	1.58105	3.81110+01
.80	1.00915	3.00778	4.01693	27.34420	1.78251	6.06052+01
1.00	1.01440	3.00736	4.02177	26.87794	1.98477	9.65539+01
1.20	1.02320	3.00695	4.03015	26.40851	2.18852	1.54355+02
1.40	1.03707	3.00732	4.04439	25.93473	2.39436	2.47948+02
1.60	1.05939	3.00836	4.06775	25.45346	2.60361	4.01430+02
1.80	1.09590	3.01052	4.10642	24.96005	2.81833	6.58158+02
2.00	1.15725	3.01492	4.17217	24.44689	3.04198	1.10149+03
2.20	1.26367	3.02457	4.28824	23.90142	3.28019	1.90629+03
2.40	1.45880	3.04714	4.50593	23.30189	3.54255	3.48779+03
2.60	1.85039	3.10776	4.95815	22.61167	3.84582	7.01165+03
2.80	2.72318	3.28710	6.01028	21.76522	4.21363	1.63542+04
3.00	4.91079	3.82083	8.73162	20.62961	4.66971	4.67423+04

T= 2700 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.02274	4.02422	29.32320	.99559	9.89897+00
.20	1.00229	3.02273	4.02502	28.86182	1.19594	1.57015+01
.40	1.00363	3.02273	4.02636	28.39996	1.39652	2.49184+01
.60	1.00576	3.02270	4.02846	27.93729	1.59744	3.95767+01
.80	1.00915	3.02274	4.03189	27.47344	1.79890	6.29361+01
1.00	1.01446	3.02235	4.03681	27.00720	2.00118	1.00272+02
1.20	1.02319	3.02196	4.04515	26.53778	2.20490	1.60288+02
1.40	1.03702	3.02235	4.05937	26.06404	2.41073	2.57472+02
1.60	1.05926	3.02345	4.08272	25.58286	2.61995	4.16821+02
1.80	1.09565	3.02571	4.12137	25.08964	2.83462	6.83313+02
2.00	1.15673	3.03028	4.18700	24.57681	3.05818	1.14335+03
2.20	1.26251	3.04014	4.30265	24.03193	3.29618	1.97779+03
2.40	1.45595	3.06288	4.51884	23.43343	3.55809	3.61485+03
2.60	1.84240	3.12298	4.96537	22.74495	3.86033	7.24987+03
2.80	2.69933	3.29785	5.99718	21.90071	4.22620	1.68345+04
3.00	4.83922	3.81279	8.65201	20.76610	4.67972	4.78322+04

T= 2800 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.03796	4.03944	29.44810	1.01138	1.02655+01
.20	1.00229	3.03796	4.04025	28.98673	1.21173	1.62828+01
.40	1.00363	3.03796	4.04159	28.52488	1.41232	2.58416+01
.60	1.00576	3.03794	4.04370	28.06221	1.61324	4.10431+01
.80	1.00915	3.03800	4.04715	27.59839	1.81470	6.52680+01
1.00	1.01451	3.03764	4.05216	27.13216	2.01700	1.03992+02
1.20	1.02319	3.03727	4.06046	26.66274	2.22070	1.66226+02
1.40	1.03696	3.03768	4.07464	26.18904	2.42650	2.66993+02
1.60	1.05914	3.03883	4.09797	25.70795	2.63569	4.32205+02
1.80	1.09540	3.04118	4.13658	25.21490	2.85032	7.08468+02
2.00	1.15621	3.04588	4.20209	24.70238	3.07378	1.18517+03
2.20	1.26137	3.05591	4.31728	24.15802	3.31158	2.04918+03
2.40	1.45322	3.07875	4.53198	23.56045	3.57307	3.74171+03
2.60	1.83481	3.13821	4.97302	22.87351	3.87433	7.48738+03
2.80	2.67704	3.30869	5.98573	22.03116	4.23840	1.73141+04
3.00	4.77283	3.80599	8.57882	20.89730	4.68952	4.89238+04

T= 2900 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.05180	4.05328	29.56880	1.02662	1.06321+01
.20	1.00229	3.05182	4.05411	29.10746	1.22697	1.68644+01
.40	1.00363	3.05183	4.05546	28.64561	1.42756	2.67646+01
.60	1.00576	3.05180	4.05756	28.18294	1.62848	4.25089+01
.80	1.00915	3.05188	4.06103	27.71912	1.82994	6.75990+01
1.00	1.01456	3.05155	4.06611	27.25291	2.03226	1.07711+02
1.20	1.02318	3.05119	4.07437	26.78350	2.23593	1.72159+02
1.40	1.03690	3.05162	4.08852	26.30982	2.44172	2.76516+02
1.60	1.05901	3.05281	4.11181	25.82882	2.65088	4.47590+02
1.80	1.09516	3.05522	4.15038	25.33592	2.86546	7.33601+02
2.00	1.15570	3.06003	4.21573	24.82367	3.08883	1.22696+03
2.20	1.26026	3.07018	4.33044	24.27979	3.32644	2.12051+03
2.40	1.45059	3.09304	4.54363	23.68304	3.58753	3.86839+03
2.60	1.82762	3.15176	4.97938	22.99744	3.88787	7.72449+03
2.80	2.65617	3.31794	5.97411	22.15669	4.25024	1.77926+04
3.00	4.71091	3.79868	8.50959	21.02346	4.69909	5.00138+04

T= 3000 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.06474	4.06622	29.68590	1.04135	1.09989+01
.20	1.00228	3.06477	4.06705	29.22456	1.24170	1.74462+01
.40	1.00363	3.06480	4.06843	28.76274	1.44228	2.76873+01
.60	1.00576	3.06475	4.07052	28.30005	1.64320	4.39744+01
.80	1.00914	3.06483	4.07397	27.83624	1.84466	6.99294+01
1.00	1.01461	3.06454	4.07914	27.37006	2.04700	1.11429+02
1.20	1.02318	3.06419	4.08736	26.90064	2.25066	1.78098+02
1.40	1.03685	3.06463	4.10147	26.42699	2.45642	2.86036+02
1.60	1.05888	3.06584	4.12472	25.94606	2.66555	4.62967+02
1.80	1.09491	3.06831	4.16322	25.45329	2.88008	7.58717+02
2.00	1.15520	3.07319	4.22839	24.94127	3.10336	1.26870+03
2.20	1.25918	3.08341	4.34259	24.39780	3.34079	2.19174+03
2.40	1.44806	3.10622	4.55428	23.80178	3.60149	3.99475+03
2.60	1.82081	3.16413	4.98494	23.11734	3.90097	7.96104+03
2.80	2.63661	3.32609	5.96270	22.27795	4.26175	1.82705+04
3.00	4.65315	3.79131	8.44447	21.14522	4.70845	5.11034+04

T= 3100 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.07801	4.07949	29.79940	1.05559	1.13655+01
.20	1.00228	3.07803	4.08032	29.33806	1.25593	1.80273+01
.40	1.00363	3.07808	4.08172	28.87626	1.45652	2.86101+01
.60	1.00577	3.07802	4.08379	28.41354	1.65744	4.54402+01
.80	1.00914	3.07809	4.08723	27.94973	1.85889	7.22587+01
1.00	1.01465	3.07785	4.09250	27.48359	2.06126	1.15149+02
1.20	1.02317	3.07750	4.10068	27.01417	2.26489	1.84031+02
1.40	1.03679	3.07795	4.11474	26.54054	2.47064	2.95556+02
1.60	1.05876	3.07918	4.13794	26.05966	2.67974	4.78344+02
1.80	1.09467	3.08169	4.17636	25.56701	2.89423	7.83845+02
2.00	1.15471	3.08662	4.24133	25.05521	3.11742	1.31045+03
2.20	1.25813	3.09687	4.35500	24.51211	3.35467	2.26292+03
2.40	1.44562	3.11958	4.56520	23.91673	3.61500	4.12098+03
2.60	1.81435	3.17662	4.99096	23.23331	3.91366	8.19710+03
2.80	2.61826	3.33447	5.95273	22.39504	4.27296	1.87482+04
3.00	4.59915	3.78504	8.38419	21.26267	4.71762	5.21939+04

T= 3200 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.08992	4.09140	29.90950	1.06938	1.17322+01
.20	1.00228	3.08992	4.09220	29.44814	1.26972	1.86089+01
.40	1.00363	3.08997	4.09360	28.98633	1.47031	2.95332+01
.60	1.00577	3.08990	4.09568	28.52362	1.67123	4.69062+01
.80	1.00912	3.09000	4.09912	28.05983	1.87268	7.45899+01
1.00	1.01469	3.08979	4.10448	27.59372	2.07507	1.18869+02
1.20	1.02317	3.08945	4.11262	27.12430	2.27868	1.89968+02
1.40	1.03673	3.08991	4.12664	26.65069	2.48440	3.05070+02
1.60	1.05863	3.09115	4.14978	26.16986	2.69348	4.93719+02
1.80	1.09443	3.09368	4.18812	25.67732	2.90792	8.08947+02
2.00	1.15423	3.09865	4.25288	25.16571	3.13103	1.35217+03
2.20	1.25713	3.10891	4.36604	24.62294	3.36811	2.33405+03
2.40	1.44329	3.13148	4.57478	24.02815	3.62809	4.24708+03
2.60	1.80821	3.18762	4.99583	23.34562	3.92598	8.43296+03
2.80	2.60098	3.34146	5.94244	22.50829	4.28387	1.92252+04
3.00	4.54850	3.77810	8.32660	21.37607	4.72660	5.32844+04

T= 3300 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00148	3.10177	4.10325	30.01660	1.08274	1.20987+01
.20	1.00228	3.10174	4.10401	29.55520	1.28309	1.91907+01
.40	1.00363	3.10176	4.10539	29.09337	1.48367	3.04558+01
.60	1.00578	3.10170	4.10748	28.63067	1.68460	4.83727+01
.80	1.00911	3.10184	4.11095	28.16693	1.88604	7.69201+01
1.00	1.01473	3.10166	4.11639	27.70084	2.08845	1.22589+02
1.20	1.02316	3.10134	4.12450	27.23141	2.29204	1.95903+02
1.40	1.03668	3.10179	4.13847	26.75782	2.49774	3.14586+02
1.60	1.05851	3.10304	4.16155	26.27704	2.70679	5.09085+02
1.80	1.09420	3.10560	4.19980	25.78460	2.92119	8.34046+02
2.00	1.15377	3.11059	4.26435	25.27317	3.14422	1.39386+03
2.20	1.25615	3.12083	4.37698	24.73070	3.38114	2.40514+03
2.40	1.44106	3.14324	4.58429	24.13643	3.64078	4.37301+03
2.60	1.80238	3.19846	5.00084	23.45470	3.93794	8.66842+03
2.80	2.58471	3.34840	5.93312	22.61815	4.29451	1.97020+04
3.00	4.50092	3.77188	8.27279	21.48601	4.73540	5.43751+04

T= 3400 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00149	3.11372	4.11521	30.12070	1.09571	1.24655+01
.20	1.00228	3.11363	4.11591	29.65924	1.29605	1.97720+01
.40	1.00363	3.11360	4.11723	29.19736	1.49664	3.13791+01
.60	1.00578	3.11358	4.11936	28.73469	1.69756	4.98379+01
.80	1.00910	3.11379	4.12288	28.27102	1.89899	7.92483+01
1.00	1.01476	3.11362	4.12838	27.80494	2.10143	1.26308+02
1.20	1.02315	3.11330	4.13646	27.33552	2.30500	2.01837+02
1.40	1.03663	3.11376	4.15039	26.86194	2.51069	3.24108+02
1.60	1.05840	3.11502	4.17341	26.38120	2.71971	5.24457+02
1.80	1.09397	3.11758	4.21156	25.88885	2.93407	8.59152+02
2.00	1.15332	3.12258	4.27590	25.37758	3.15701	1.43552+03
2.20	1.25520	3.13279	4.38800	24.83538	3.39378	2.47617+03
2.40	1.43892	3.15500	4.59392	24.24157	3.65310	4.49883+03
2.60	1.79686	3.20928	5.00614	23.56054	3.94958	8.90389+03
2.80	2.56939	3.35549	5.92487	22.72467	4.30489	2.01786+04
3.00	4.45616	3.76655	8.22271	21.59257	4.74402	5.54651+04

T= 3500 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00150	3.12419	4.12569	30.22220	1.10830	1.28322+01
.20	1.00229	3.12403	4.12631	29.76067	1.30864	2.03535+01
.40	1.00363	3.12391	4.12755	29.29870	1.50923	3.23020+01
.60	1.00577	3.12395	4.12972	28.83609	1.71015	5.13039+01
.80	1.00908	3.12425	4.13333	28.37252	1.91158	8.15793+01
1.00	1.01480	3.12409	4.13888	27.90644	2.11403	1.30026+02
1.20	1.02315	3.12378	4.14693	27.43701	2.31759	2.07773+02
1.40	1.03658	3.12424	4.16082	26.96345	2.52325	3.33618+02
1.60	1.05828	3.12549	4.18378	26.48274	2.73225	5.39821+02
1.80	1.09376	3.12806	4.22181	25.99046	2.94657	8.84240+02
2.00	1.15288	3.13305	4.28593	25.47933	3.16944	1.47720+03
2.20	1.25429	3.14321	4.39750	24.93738	3.40605	2.54712+03
2.40	1.43686	3.16519	4.60204	24.34399	3.66506	4.62445+03
2.60	1.79159	3.21853	5.01012	23.66358	3.96089	9.13882+03
2.80	2.55490	3.36118	5.91607	22.82834	4.31502	2.06548+04
3.00	4.41395	3.76069	8.17465	21.69644	4.75248	5.65562+04

T= 3600 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00151	3.13520	4.13671	30.32110	1.12054	1.31990+01
.20	1.00230	3.13493	4.13723	29.85945	1.32088	2.09353+01
.40	1.00364	3.13471	4.13835	29.39738	1.52146	3.32246+01
.60	1.00576	3.13477	4.14053	28.93479	1.72238	5.27691+01
.80	1.00906	3.13514	4.14420	28.47130	1.92380	8.39073+01
1.00	1.01483	3.13498	4.14981	28.00522	2.12628	1.33746+02
1.20	1.02314	3.13469	4.15783	27.53579	2.32982	2.13708+02
1.40	1.03653	3.13514	4.17167	27.06224	2.53547	3.43139+02
1.60	1.05817	3.13639	4.19456	26.58157	2.74444	5.55188+02
1.80	1.09354	3.13895	4.23249	26.08935	2.95872	9.09327+02
2.00	1.15246	3.14393	4.29639	25.57835	3.18151	1.51883+03
2.20	1.25342	3.15401	4.40743	25.03660	3.41798	2.61806+03
2.40	1.43488	3.17574	4.61062	24.44358	3.67670	4.75007+03
2.60	1.78658	3.22814	5.01472	23.76371	3.97191	9.37368+03
2.80	2.54119	3.36735	5.90855	22.92901	4.32492	2.11310+04
3.00	4.37407	3.75594	8.13001	21.79728	4.76077	5.76461+04

T= 3700 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00153	3.14525	4.14678	30.41780	1.13245	1.35659+01
.20	1.00231	3.14483	4.14714	29.95599	1.33279	2.15174+01
.40	1.00365	3.14450	4.14815	29.49380	1.53337	3.41484+01
.60	1.00574	3.14448	4.15022	29.03113	1.73427	5.42338+01
.80	1.00905	3.14483	4.15387	28.56763	1.93570	8.62383+01
1.00	1.01486	3.14469	4.15955	28.10157	2.13819	1.37464+02
1.20	1.02314	3.14440	4.16754	27.63214	2.34172	2.19644+02
1.40	1.03648	3.14485	4.18133	27.15860	2.54735	3.52655+02
1.60	1.05807	3.14610	4.20416	26.67795	2.75630	5.70558+02
1.80	1.09333	3.14865	4.24198	26.18580	2.97054	9.34415+02
2.00	1.15205	3.15360	4.30565	25.67491	3.19326	1.56049+03
2.20	1.25258	3.16360	4.41618	25.13335	3.42959	2.68900+03
2.40	1.43299	3.18506	4.61805	24.54065	3.68803	4.87562+03
2.60	1.78180	3.23651	5.01831	23.86125	3.98264	9.60816+03
2.80	2.52819	3.37237	5.90056	23.02697	4.33459	2.16068+04
3.00	4.33636	3.75046	8.08682	21.89526	4.76891	5.87368+04

T= 3800 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00157	3.15646	4.15803	30.51240	1.14405	1.39332+01
.20	1.00234	3.15584	4.15818	30.05038	1.34438	2.20994+01
.40	1.00367	3.15538	4.15905	29.58804	1.54496	3.50720+01
.60	1.00573	3.15517	4.16091	29.12519	1.74585	5.56993+01
.80	1.00903	3.15541	4.16444	28.66159	1.94727	8.85666+01
1.00	1.01489	3.15532	4.17020	28.19556	2.14978	1.41182+02
1.20	1.02313	3.15503	4.17816	27.72613	2.35330	2.25580+02
1.40	1.03644	3.15548	4.19191	27.25259	2.55891	3.62168+02
1.60	1.05796	3.15671	4.21468	26.77197	2.76784	5.85922+02
1.80	1.09313	3.15925	4.25239	26.27988	2.98204	9.59489+02
2.00	1.15165	3.16418	4.31583	25.76909	3.20469	1.60210+03
2.20	1.25177	3.17408	4.42584	25.22770	3.44089	2.75988+03
2.40	1.43118	3.19526	4.62644	24.63529	3.69906	5.00104+03
2.60	1.77727	3.24575	5.02301	23.95629	3.99312	9.84283+03
2.80	2.51588	3.37835	5.89423	23.12233	4.34406	2.20831+04
3.00	4.30062	3.74643	8.04705	21.99054	4.77690	5.98274+04

T= 3900 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00162	3.16696	4.16858	30.60510	1.15535	1.43005+01
.20	1.00238	3.16608	4.16846	30.14281	1.35568	2.26819+01
.40	1.00369	3.16549	4.16918	29.68032	1.55625	3.59956+01
.60	1.00575	3.16498	4.17073	29.21715	1.75714	5.71663+01
.80	1.00901	3.16501	4.17402	28.75335	1.95854	9.08950+01
1.00	1.01491	3.16497	4.17989	28.28738	2.16108	1.44904+02
1.20	1.02313	3.16468	4.18781	27.81794	2.36458	2.31515+02
1.40	1.03639	3.16513	4.20152	27.34441	2.57017	3.71681+02
1.60	1.05786	3.16635	4.22421	26.86381	2.77908	6.01284+02
1.80	1.09294	3.16868	4.26182	26.37177	2.99324	9.84555+02
2.00	1.15127	3.17377	4.32504	25.86106	3.21583	1.64373+03
2.20	1.25098	3.18356	4.43455	25.31983	3.45190	2.83074+03
2.40	1.42944	3.20445	4.63389	24.72767	3.70981	5.12637+03
2.60	1.77292	3.25398	5.02690	24.04902	4.00334	1.00772+04
2.80	2.50420	3.38346	5.88766	23.21533	4.35332	2.25590+04
3.00	4.26674	3.74201	8.00874	22.08345	4.78474	6.09172+04

T= 4000 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00168	3.17711	4.17879	30.69600	1.16637	1.46680+01
.20	1.00243	3.17593	4.17835	30.23337	1.36670	2.32648+01
.40	1.00372	3.17517	4.17890	29.77071	1.56726	3.69199+01
.60	1.00578	3.17425	4.18003	29.30711	1.76815	5.86341+01
.80	1.00899	3.17357	4.18296	28.84299	1.96953	9.32245+01
1.00	1.01494	3.17400	4.18894	28.37709	2.17208	1.48621+02
1.20	1.02312	3.17370	4.19682	27.90764	2.37557	2.37449+02
1.40	1.03635	3.17415	4.21050	27.43412	2.58115	3.81197+02
1.60	1.05777	3.17536	4.23312	26.95353	2.79003	6.16638+02
1.80	1.09275	3.17787	4.27062	26.46154	3.00416	1.00962+03
2.00	1.15090	3.18271	4.33361	25.95092	3.22668	1.68531+03
2.20	1.25023	3.19239	4.44262	25.40981	3.46263	2.90155+03
2.40	1.42778	3.21298	4.64075	24.81788	3.72030	5.25170+03
2.60	1.76879	3.26156	5.03035	24.13952	4.01332	1.03115+04
2.80	2.49308	3.38803	5.88111	23.30607	4.36238	2.30346+04
3.00	4.23454	3.73758	7.97212	22.17415	4.79245	6.20083+04

T= 4100 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00177	3.18815	4.18992	30.78560	1.17714	1.50363+01
.20	1.00249	3.18651	4.18900	30.32248	1.37745	2.38479+01
.40	1.00377	3.18548	4.18925	29.85953	1.57800	3.78443+01
.60	1.00586	3.18404	4.18990	29.39538	1.77890	6.01035+01
.80	1.00897	3.18342	4.19239	28.93091	1.98024	9.55520+01
1.00	1.01496	3.18354	4.19850	28.46510	2.18282	1.52342+02
1.20	1.02312	3.18323	4.20635	27.99562	2.38629	2.43383+02
1.40	1.03631	3.18367	4.21998	27.52211	2.59186	3.90715+02
1.60	1.05767	3.18486	4.24254	27.04154	2.80072	6.32004+02
1.80	1.09257	3.18736	4.27993	26.54959	3.01482	1.03471+03
2.00	1.15055	3.19215	4.34270	26.03904	3.23727	1.72691+03
2.20	1.24950	3.20171	4.45122	25.49805	3.47310	2.97235+03
2.40	1.42617	3.22159	4.64817	24.90631	3.73054	5.37700+03
2.60	1.76484	3.26965	5.03449	24.22822	4.02307	1.05456+04
2.80	2.48249	3.39325	5.87574	23.39499	4.37125	2.35099+04
3.00	4.20392	3.73427	7.93819	22.26307	4.80002	6.30986+04

T= 4200 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00190	3.19930	4.20120	30.87390	1.18766	1.54049+01
.20	1.00257	3.19696	4.19953	30.41003	1.38795	2.44315+01
.40	1.00383	3.19543	4.19925	29.94654	1.58849	3.87695+01
.60	1.00596	3.19341	4.19937	29.48178	1.78941	6.15758+01
.80	1.00895	3.19250	4.20144	29.01700	1.99070	9.78814+01
1.00	1.01499	3.19269	4.20768	28.55126	2.19329	1.56059+02
1.20	1.02311	3.19237	4.21548	28.08177	2.39676	2.49322+02
1.40	1.03627	3.19281	4.22908	27.60827	2.60231	4.00230+02
1.60	1.05758	3.19398	4.25157	27.12771	2.81115	6.47366+02
1.80	1.09239	3.19646	4.28885	26.63580	3.02521	1.05977+03
2.00	1.15021	3.20121	4.35141	26.12531	3.24761	1.76852+03
2.20	1.24881	3.21064	4.45945	25.58443	3.48333	3.04320+03
2.40	1.42464	3.23062	4.65526	24.99288	3.74054	5.50225+03
2.60	1.76107	3.27739	5.03846	24.31502	4.03261	1.07798+04
2.80	2.47245	3.39824	5.87069	23.48198	4.37996	2.39861+04
3.00	4.17476	3.73118	7.90594	22.35010	4.80746	6.41889+04

T= 4300 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00206	3.21195	4.21401	30.96130	1.19795	1.57743+01
.20	1.00270	3.20864	4.21133	30.49639	1.39822	2.50161+01
.40	1.00391	3.20636	4.21027	30.03211	1.59875	3.96963+01
.60	1.00609	3.20372	4.20981	29.56667	1.79969	6.30507+01
.80	1.00892	3.20256	4.21148	29.10162	2.00091	1.00210+02
1.00	1.01501	3.20281	4.21782	28.63595	2.20352	1.59779+02
1.20	1.02311	3.20248	4.22559	28.16644	2.40697	2.55253+02
1.40	1.03623	3.20292	4.23915	27.69295	2.61251	4.09742+02
1.60	1.05749	3.20408	4.26157	27.21240	2.82133	6.62720+02
1.80	1.09222	3.20653	4.29876	26.72053	3.03536	1.08483+03
2.00	1.14987	3.21123	4.36110	26.21010	3.25770	1.81009+03
2.20	1.24813	3.22054	4.46868	25.66932	3.49331	3.11394+03
2.40	1.42316	3.24023	4.66339	25.07794	3.75031	5.62743+03
2.60	1.75746	3.28614	5.04359	24.40031	4.04194	1.10139+04
2.80	2.46279	3.40439	5.86718	23.56750	4.38848	2.44613+04
3.00	4.14695	3.72971	7.87666	22.43576	4.81478	6.52800+04

T= 4400 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00227	3.22424	4.22651	31.04810	1.20802	1.61443+01
.20	1.00286	3.21967	4.22254	30.58185	1.40828	2.56024+01
.40	1.00404	3.21638	4.22042	30.11650	1.60879	4.06247+01
.60	1.00624	3.21305	4.21929	29.65029	1.80974	6.45268+01
.80	1.00890	3.21171	4.22061	29.18503	2.01088	1.02537+02
1.00	1.01503	3.21201	4.22704	28.71941	2.21351	1.63497+02
1.20	1.02310	3.21168	4.23478	28.24990	2.41695	2.61186+02
1.40	1.03619	3.21211	4.24831	27.77641	2.62248	4.19257+02
1.60	1.05741	3.21325	4.27066	27.29587	2.83128	6.78079+02
1.80	1.09206	3.21568	4.30774	26.80403	3.04528	1.10989+03
2.00	1.14955	3.22032	4.36988	26.29365	3.26757	1.85170+03
2.20	1.24749	3.22952	4.47701	25.75297	3.50307	3.18471+03
2.40	1.42174	3.24892	4.67066	25.16175	3.75986	5.75254+03
2.60	1.75399	3.29402	5.04801	24.48436	4.05106	1.12476+04
2.80	2.45365	3.40983	5.86348	23.65179	4.39685	2.49373+04
3.00	4.12040	3.72803	7.84843	22.52031	4.82198	6.63713+04

T= 4500 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00254	3.23859	4.24113	31.13450	1.21790	1.65158+01
.20	1.00309	3.23247	4.23556	30.66658	1.41814	2.61903+01
.40	1.00421	3.22789	4.23210	30.19985	1.61862	4.15547+01
.60	1.00641	3.22380	4.23021	29.73280	1.81957	6.60040+01
.80	1.00887	3.22235	4.23122	29.26740	2.02063	1.04865+02
1.00	1.01505	3.22268	4.23773	28.80181	2.22328	1.67217+02
1.20	1.02310	3.22235	4.24544	28.33229	2.42671	2.67122+02
1.40	1.03616	3.22278	4.25894	27.85881	2.63222	4.28766+02
1.60	1.05733	3.22390	4.28123	27.37828	2.84101	6.93442+02
1.80	1.09190	3.22630	4.31821	26.88647	3.05498	1.13496+03
2.00	1.14925	3.23089	4.38013	26.37614	3.27721	1.89326+03
2.20	1.24686	3.23997	4.48683	25.83555	3.51261	3.25544+03
2.40	1.42038	3.25910	4.67948	25.24449	3.76920	5.87760+03
2.60	1.75068	3.30343	5.05411	24.56734	4.06000	1.14815+04
2.80	2.44486	3.41698	5.86184	23.73508	4.40505	2.54127+04
3.00	4.09499	3.72857	7.82356	22.60406	4.82905	6.74606+04

T= 4600 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00288	3.25321	4.25609	31.22080	1.22759	1.68885+01
.20	1.00338	3.24535	4.24873	30.75099	1.42781	2.67800+01
.40	1.00443	3.23930	4.24374	30.28267	1.62826	4.24874+01
.60	1.00659	3.23441	4.24100	29.81472	1.82919	6.74823+01
.80	1.00884	3.23287	4.24171	29.34920	2.03016	1.07191+02
1.00	1.01507	3.23322	4.24829	28.88365	2.23284	1.70939+02
1.20	1.02309	3.23289	4.25599	28.41411	2.43626	2.73061+02
1.40	1.03612	3.23332	4.26944	27.94064	2.64175	4.38278+02
1.60	1.05725	3.23443	4.29168	27.46012	2.85052	7.08794+02
1.80	1.09175	3.23680	4.32855	26.96833	3.06446	1.16001+03
2.00	1.14895	3.24133	4.39027	26.45804	3.28664	1.93482+03
2.20	1.24626	3.25029	4.49655	25.91753	3.52195	3.32621+03
2.40	1.41906	3.26914	4.68820	25.32661	3.77834	6.00261+03
2.60	1.74749	3.31270	5.06019	24.64966	4.06876	1.17155+04
2.80	2.43645	3.42401	5.86046	23.81762	4.41310	2.58881+04
3.00	4.07065	3.72912	7.79978	22.68690	4.83601	6.85504+04

T= 4700 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00331	3.26953	4.27284	31.30750	1.23712	1.72631+01
.20	1.00374	3.25985	4.26359	30.83568	1.43730	2.73716+01
.40	1.00471	3.25228	4.25699	30.36569	1.63772	4.34230+01
.60	1.00678	3.24655	4.25333	29.89679	1.83862	6.89636+01
.80	1.00882	3.24492	4.25374	29.43115	2.03949	1.09519+02
1.00	1.01509	3.24530	4.26039	28.96563	2.24218	1.74655+02
1.20	1.02309	3.24497	4.26806	28.49609	2.44559	2.78991+02
1.40	1.03609	3.24539	4.28148	28.02262	2.65108	4.47796+02
1.60	1.05717	3.24648	4.30366	27.54211	2.85983	7.24152+02
1.80	1.09160	3.24882	4.34042	27.05033	3.07374	1.18506+03
2.00	1.14866	3.25328	4.40194	26.54008	3.29587	1.97638+03
2.20	1.24568	3.26212	4.50779	25.99962	3.53109	3.39696+03
2.40	1.41779	3.28066	4.69845	25.40880	3.78729	6.12759+03
2.60	1.74443	3.32338	5.06781	24.73194	4.07733	1.19490+04
2.80	2.42835	3.43232	5.86067	23.89991	4.42099	2.63627+04
3.00	4.04735	3.73073	7.77808	22.76898	4.84285	6.96386+04

T= 4800 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00384	3.28784	4.29168	31.39480	1.24649	1.76397+01
.20	1.00417	3.27627	4.28044	30.92087	1.44663	2.79660+01
.40	1.00505	3.26711	4.27216	30.44911	1.64701	4.43619+01
.60	1.00699	3.26051	4.26749	29.97921	1.84785	7.04450+01
.80	1.00879	3.25880	4.26758	29.51345	2.04862	1.11846+02
1.00	1.01511	3.25920	4.27430	29.04796	2.25134	1.78377+02
1.20	1.02309	3.25887	4.28195	28.57841	2.45474	2.84931+02
1.40	1.03606	3.25928	4.29534	28.10495	2.66021	4.57309+02
1.60	1.05710	3.26036	4.31746	27.62444	2.86894	7.39503+02
1.80	1.09146	3.26266	4.35412	27.13268	3.08283	1.21012+03
2.00	1.14838	3.26705	4.41543	26.62244	3.30491	2.01795+03
2.20	1.24512	3.27574	4.52085	26.08203	3.54003	3.46761+03
2.40	1.41658	3.29394	4.71052	25.49126	3.79607	6.25273+03
2.60	1.74151	3.33577	5.07728	24.81439	4.08575	1.21829+04
2.80	2.42061	3.44221	5.86282	23.98214	4.42875	2.68380+04
3.00	4.02506	3.73366	7.75872	22.85046	4.84960	7.07294+04

T= 4900 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00448	3.30852	4.31300	31.48320	1.25572	1.80186+01
.20	1.00467	3.29498	4.29965	31.00704	1.45580	2.85627+01
.40	1.00544	3.28417	4.28962	30.53343	1.65614	4.53044+01
.60	1.00720	3.27667	4.28387	30.06248	1.85689	7.19267+01
.80	1.00876	3.27486	4.28362	29.59659	2.05757	1.14175+02
1.00	1.01512	3.27529	4.29041	29.13114	2.26030	1.82096+02
1.20	1.02308	3.27496	4.29804	28.66158	2.46369	2.90864+02
1.40	1.03603	3.27537	4.31140	28.18812	2.66915	4.66821+02
1.60	1.05703	3.27643	4.33346	27.70761	2.87787	7.54866+02
1.80	1.09132	3.27869	4.37001	27.21586	3.09173	1.23518+03
2.00	1.14811	3.28259	4.43111	26.70563	3.31376	2.05949+03
2.20	1.24458	3.29153	4.53610	26.16524	3.54880	3.53834+03
2.40	1.41541	3.30937	4.72478	25.57448	3.80466	6.37764+03
2.60	1.73870	3.35024	5.08894	24.89751	4.09400	1.24165+04
2.80	2.41323	3.45404	5.86728	24.06478	4.43638	2.73137+04
3.00	4.00373	3.73830	7.74204	22.93185	4.85624	7.18191+04

T= 5000 NITROGEN

LOG RHO	Z	E/RT	H/RT	S/R	LOG P	P
.00	1.00527	3.33094	4.33621	31.57300	1.26483	1.84005+01
.20	1.00524	3.31536	4.32060	31.09450	1.46482	2.91622+01
.40	1.00589	3.30283	4.30873	30.61894	1.66511	4.62498+01
.60	1.00742	3.29439	4.30182	30.14690	1.86577	7.34125+01
.80	1.00873	3.29250	4.30123	29.68087	2.06633	1.16501+02
1.00	1.01514	3.29295	4.30809	29.21546	2.26908	1.85815+02
1.20	1.02308	3.29262	4.31570	28.74590	2.47246	2.96797+02
1.40	1.03600	3.29302	4.32902	28.27243	2.67791	4.76332+02
1.60	1.05696	3.29406	4.35102	27.79193	2.88661	7.70212+02
1.80	1.09119	3.29627	4.38746	27.30017	3.10045	1.26023+03
2.00	1.14786	3.30049	4.44835	26.78995	3.32244	2.10107+03
2.20	1.24406	3.30865	4.55291	26.24955	3.55739	3.60903+03
2.40	1.41429	3.32631	4.74060	25.65876	3.81309	6.50264+03
2.60	1.73602	3.36617	5.10218	24.98159	4.10211	1.26506+04
2.80	2.40621	3.46720	5.87340	24.14816	4.44389	2.77901+04
3.00	3.98335	3.74404	7.72739	23.01347	4.86280	7.29122+04

Security Classification

DOCUMENT CONTROL DATA - R&D

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1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Arnold Engineering Development Center ARO, Inc., Operating Contractor Arnold Air Force Station, Tennessee	UNCLASSIFIED
	2b GROUP N/A

3 REPORT TITLE

THERMODYNAMIC PROPERTIES OF NITROGEN FROM 300 TO 5000°K AND FROM 1 TO 1000 AMAGATS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

N/A

5. AUTHOR(S) (Last name, first name, initial)

Grabau, Martin and Brahinsky, H. S., ARO, Inc.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
August 1966	62	18

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
AF40(600)-1200 Program Element 65402234	AEDC-TR-66-69
	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A

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N/A	Arnold Engineering Development Center(AEDC) Air Force Systems Command(AFSC) Arnold Air Force Station, Tennessee

13 ABSTRACT

Tables for the thermodynamic properties of equilibrium nitrogen are presented at intervals of log $\rho = 0.2$, the density ρ in amagats extending from one to 1000 amagats, and at intervals of 100 deg from 300 to 5000°K. In accordance with full discussion in the text of the report, the compressibility factor Z at 300 and 400°K is extrapolated to 1000 amagats by linear extrapolation of log (Z-1) against log ρ at constant temperature. At 3000 and 5000°K the values of Z are found from published virial coefficients. Interpolations between these extremes of temperature are based on an empirical equation for the pressure-temperature lines at constant density, the form of which fits known data at medium densities and also predicts data at temperatures below 300°K. The values of the dimensionless thermal functions E/RT (internal energy) and S/R (entropy) are based on numerical integrations of Z and its derivative $(\partial Z/\partial T)_\rho$, using known values of these functions at one amagat as constants of integration. This method of determining the thermal functions is validated by showing that it reproduces a set of known tables to a high degree of accuracy.

DD FORM 1 JAN 64 1473

Security Classification

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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thermodynamic properties						
temperature						
density						
pressure						
energy						

4-11

1. Nitrogen -- Properties

2. " -- Thermodynamic properties

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